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ST. LOUIS MEETING

The National Association for Research in Science Teaching and The National Association of Biology Teachers are co-sponsoring a program at the December St. Louis meeting of The American Association for the Advancement of Science. It is hoped that readers of *Science Education* and members of NARST will respond immediately to the request of Professor Kenneth E. Anderson whose letter and call for research papers appears below.

School of Education
University of Kansas
July 30, 1952

Dear NARST Member:

The NARST and the NABT are co-sponsoring the program for the National Association of Biology Teachers for the St. Louis meeting of the AAAS in December.

This letter, therefore, constitutes a call for papers on the teaching of biology for the St. Louis meeting. If you or your graduate students wish to present a paper at this meeting, please submit the information called for in the seven point outline. *Be as brief as possible, but in any event do not write more than can be easily contained on one typewritten sheet.*

1. Title
2. Author
3. Institution in which the study was made
4. Date of completion of the study
5. Statement of the problem
6. A description of the methods and techniques employed
7. A list of the significant findings and conclusions

This letter also constitutes a call for papers for our own meeting of the NARST in February. Here again, if you or your graduate students wish to present a paper at this meeting, submit the information called for in the outline.

The deadline for papers for the St. Louis meeting in December is November 15. The deadline for papers for the NARST meeting in February is January 10.

The cooperation of all members is needed in order to professionalize the teaching of science at all levels.

Sincerely yours,

KENNETH E. ANDERSON
Director, Bureau of
Educational Research
and Service
School of Education
University of Kansas
Lawrence, Kansas

CALL FOR PAPERS

(1) Plan now to attend the co-sponsored meeting in St. Louis in December and give a report of your research in biology or the teaching of biology! The meeting is sponsored by the National Association for Research in Science Teaching and the National Association of Biology Teachers.

(2) Plan now to attend the annual convention of the National Association for Research in Science Teaching in February and present the research you have done or are now doing in science education.

MAIL THIS FORM SOON!

Dr. Kenneth E. Anderson
Director, Bureau of Educational
Research and Service
107 Fraser Hall
University of Kansas
Lawrence, Kansas

Dear Dr. Anderson:

I wish to present the following paper entitled: ....

....

....
Name

....
Address

SCIENCE EDUCATION

VOLUME 36 OCTOBER, 1952 NUMBER 4

AN INVESTIGATION OF THE ATTITUDES OF TEACHERS TOWARD THE NEW YORK STATE REGENTS' EXAMINATIONS IN SCIENCE *

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Lakeview Junior High School, Battle Creek, Michigan

and

George Greisen Mallinson

Western Michigan College of Education, Kalamazoo, Michigan

INTRODUCTION

For many years a great difference of opinion has existed among science educators with respect to the values of the New York State Regents' Examinations in Science. These examinations are administered to high-school students who have studied certain courses in science for a period prescribed by the University of the State of New York.[1] At present science examinations are prepared for Biology, Chemistry, Physics and Earth Science. Yet despite the views expressed for and against these examinations a survey of the literature fails to reveal any major investigation with respect to their values.

As a result of the controversy concerning the Regents' Examinations, it was decided in 1946 by the New York State Science Teachers Association that a committee be appointed to ascertain the attitudes of the teachers of the State of New York with respect to the Regents' Examinations in Science, and if possible to ascertain the reliability and validity of the examinations. The chairman of the committee was Mr. Wilton E. Baty of Huntington High School, Huntington, New York.

The committee decided that in order to arrive at an unbiased evaluation of the examinations the investigation should be directed by someone outside of the State of New York who was familiar with the Regents' Examinations. Hence, the task was assigned to Dr. George G. Mallinson of Western Michigan College of Education of Kalamazoo, Michigan, who formerly taught science in the State of New York from 1937–1942.

The investigator, in turn, was delegated the portion of the study that dealt with determining the attitudes of science teachers of New York State with respect to the Regents' examinations.

THE PROBLEM

Thus, the problem of this study is to determine the attitudes of the science teachers of the State of New York with respect to the Regents' Examinations in Science.

METHODS EMPLOYED

In order to determine the attitudes of the science teachers of the State of New York with respect to the Regents' Examinations

* Paper presented at the Twenty-Fourth Annual Meeting of The National Association for Research in Science Teaching, Atlantic City, New Jersey, February 18, 1951.

[1] The term "University of the State of New York" is the official name for the governing body of the system of public education for the State of New York.

in Science it was decided to send a questionnaire to a representative sampling of them. Hence, the first step was to develop a questionnaire that would require responses concerning the chief points of controversy. These points, in essence are as follows:

1. The Regents' Examinations in Science fail to measure other than factual information.
2. The Regents' Examinations restrict the teachers greatly in what they wish to teach.
3. The Regents' Examinations are used as a measuring device of the effectiveness of the teaching process.
4. The Regents' Examinations in general lower the standards of science teaching in the State of New York.

In order to develop a questionnaire that would measure the attitudes of teachers with respect to the above points, an exhaustive search was made of the literature concerning desirable objectives of science. As a result the objectives listed in the Forty-Sixth Yearbook of the National Society for the Study of Education [2] were accepted as desirable standards against which to measure the Regents' Examinations. These objectives are as follows:

[2] *Science Education in American Schools,* Forty-Sixth Yearbook of the National Society for the Study of Education, Part 1. Distributed by the University of Chicago Press, 1947. Pp. 28–9.

1. Functional information of facts, concerning areas such as the universe, living things, and the human body.
2. Functional understandings of the major principles or generalizations of science.
3. Development of scientific attitudes.
4. Development of skills in the scientific method.

A number of conferences were held with, and letters written to, many science educators in New York State in order to obtain questions with respect to the other points mentioned. As a result of these conferences and letters a number of questions were obtained.

A tentative form of the questionnaire was then prepared. It was submitted to (1) Mr. Wilton E. Baty, Chairman of the Committee on Regents' Examinations, New York State Science Teachers Association, Huntington High School, Huntington, New York; (2) Mr. Hugh Templeton, Supervisor of Science, University of the State of New York, Albany, New York; and (3) Mr. Gordon E. Van Hooft, President, New York State Science Teachers Association, Brighton High School, Rochester, New York. A final form was then prepared that incorporated the criticisms and suggestions. A copy of the questionnaire follows:

Please return in the enclosed envelope. Do not identify yourself by a return address or a signature.

QUESTIONNAIRE ON NEW YORK REGENTS' EXAMINATIONS IN SCIENCE

(Please do not sign your name)

Please check the answers in the appropriate manner;

I. Personal Data:

A. How many years have you been teaching in New York State? ....

B. What "Regents" courses in Science have you taught in New York State? (Please check)

General Biology .... Physics ....
Chemistry .... Earth Science ....

C. What "Regents" courses in Science are you now teaching in New York State? (Please check)

General Biology .... Physics ....
Chemistry .... Earth Science ....

D. How many years have you taught science courses in states other than New York? ....

E. Please indicate the states in which you have taught science other than New York. ......
....

F. What courses in Science have you taught in those other states? (Please check)

General Science	Physics ....
General Biology	Earth Science ....
Chemistry	Physical Science ....

Others (Please list) ....
....
....

II. The following questions deal with your opinions of the Regents' Examinations in the Sciences you are now teaching or have taught in New York State. (Check the appropriate item or items)

A. Measure the topics listed in the present corresponding syllabus.
Very Well .... Fairly Well .... Poorly ....

B. Measure the achievement of the student accurately.
Very Well .... Fairly Well .... Poorly ....

C. Measure subject matter desirable for college entrance.
Very Well .... Fairly Well .... Poorly ....

D. Measure subject matter desirable for non-college students, who are headed for the farm or technical industries.
Very Well .... Fairly Well .... Poorly ....

E. Measure subject matter desirable for the general cultural development of non-college, non-technical pupils.
Very Well .... Fairly Well .... Poorly ....

F. Emphasize facts rather than understandings of Science.
Yes .... No .... No Opinion ....

III. Please indicate the extent to which the Regents' Examinations in Science emphasize the following objectives. (Check the appropriate answers)

	Too Much	*Desirable*	*Too Little*
Facts	....	....	....
Understanding of Scientific Principles	....	....	....
Development of Scientific Attitudes	....	....	....
Development of Skills in the Scientific Method	....	....	....

IV. Please give your opinion regarding the following:

A. Do you believe that teachers of Science tend in the classroom to emphasize those topics likely to be found on Regents' Examinations?
Yes .... No .... No Opinion ....

B. Do you believe that students tend to work toward passing the Regents' Examinations in Science as their primary goal rather than toward learning Science?
Yes .... No .... No Opinion ....

C. Do you believe the Regents' serve as a valuable measuring device for the:

Above average student	Yes	No	No Opinion ....
Average student	Yes	No	No Opinion ....
Below average student	Yes	No	No Opinion ....

D. Do you believe that the Science courses you taught in states other than in New York were more practical than those you teach or have taught in New York State?
Yes .... No .... No Opinion ....

E. Do you believe that the Regents' Examinations in Science tend to restrict you in what you you would like to teach?
Yes .... No .... No Opinion ....

F. How do you believe that students in New York State compare with those in other states in achieving the following objectives? (Check the appropriate blanks)

	Greater Achievement than Students in Other States	*About the Same Achievement*	*Less Achievement*
Facts	....	....	....
Understanding of Scientific Principles	....	....	....
Development of Scientic Attitudes	....	....	....
Development of Skills in the Scientific Method	....	....	....

G. To what extent do you believe that the abolition of the Regents' Examinations in Science would change the standards of teaching in Science?

Lower standards ....
No change in standards ....
Raise standards ....

V. Please check the appropriate items with respect to future Regents' Examinations in Science.

Should be discarded ....
Should be retained as is ....
Should be retained but modified ....
Should be abolished as graduation tests but retained in modified form as a tool to discover weak spots in curriculum or teaching ....

VI. Please indicate briefly what should be done to improve the quality of the Regents' Examinations in Science assuming that they are retained. (Use back of the sheet if needed)

....
....
....
....
....

VII. If Regents' Examinations in Science were modified as you have indicated in VI would you approve of their retention?

Yes .... No .... No Opinion ....

VIII. These questions tend to be miscellaneous but are frequently items of discussion with respect to the Regents' Examinations in Science. (Please indicate your answers in the appropriate blanks)

A. Do you think a scoring key should be provided with each examination?

Yes .... No .... No Opinion ....

B. Do you believe that there should be an annual report to the State of the individual teacher's Regents' Examination record, expressed in percentage of passing and failure? (This is not current practice)

Yes .... No .... No Opinion ....

C. Do you believe that the State should check for correct scoring a sample of each teacher's papers?

Yes .... No .... No Opinion ....

D. What is your opinion with respect to disposition of the Regents' papers?

	Yes
Retained in the school as the property of the school	....
Retained in the school but subject to call by the State	....
Forwarded to the State for disposition	....

E. Do you believe that in a high school Science course, such as Earth Science, Biology, Chemistry or Physics, the teachers should be required to cover the various topics in the respective field, rather than concentrating on his interest?

Yes .... No .... No Opinion ....

IX. Please comment as you choose with respect to the Regents' Examinations in Science. Under no circumstances will you be identified.

....
....
....
....
....

The next step was to decide the means for disseminating the questionnaire. As a result of conferences with the science educators already mentioned, it was decided to send questionnaires to these two groups of teachers:

1. Teachers who are now teaching "Regents" science in New York State but who formerly taught science in other states and countries. Hereafter they will be referred to as "out-staters."
2. Teachers whose experience in teaching "Regents" science has been only in New York State. Hereafter they will be referred to as "in-staters."

The distribution to the "out-staters" was carried out in this way. In February, 1950 the following letter was sent to the science teachers in New York State:

THE NEW YORK STATE SCIENCE TEACHERS ASSOCIATION

1 February 1950

A SCIENCE LETTER

The New York State Science Teachers Association is interested in making a survey of opinion of the science teachers of the State. One group of teachers whose opinions are sought on some of the items of the survey are those who have taught science in more than one state (geographically speaking). The chairman of the committee making this investigation is Wilton Baty, Huntington High School, Huntington, Long Island, New York. He has asked me if there was some way by which he could acquire a list of the science teachers with experience in other states. I can think of no other reasonable way than by this appeal to get the information he seeks.

I am certain that the questionnaire will be brief and strictly anonymous. If you are willing to make the contribution of a one-cent postcard and a few minutes' time to an investigation which I feel would be useful to all of us, jot your name and address on the postcard and send it to Mr. Baty. Later you will receive a short questionnaire and still later a copy of the results of the survey.

We estimate that we shall need the cooperation of practically all of the teachers with experience in two or more states in order to obtained valid results. Because of this I hope you will make an extra effort to contact Mr. Baty if you have had this experience. I also hope that you will make an effort to see that every member of your department has an opportunity to read this letter.

Sincerely yours,

Hugh Templeton

A total of one hundred twenty-one teachers replied. Questionnaires were sent to all of them.

The distribution to the "in-staters" was carried out thus:

Miss Agnes Hodahl[3] searched the records of the State Department of Education and obtained the names and addresses of, and courses taught by, all the science teachers in New York State. This master list included two thousand two hundred names. It was then decided to send questionnaires to a representative sampling of six hundred teachers on the list.

The sampling was made in this way:

First, the twenty-two hundred teachers on the list were classified into three groups:

1. Teachers teaching one Regents' science course.
2. Teachers teaching two Regents' science courses.
3. Teachers teaching three or four Regents' science courses.

The relative proportion of teachers within each of the three groups was then determined. This proportion in turn was

[3] New York State Representative for the National Science Teachers' Association, Albany, New York.

used in determining the number of teachers within each of the three groups to whom the six hundred questionnaires were to be sent. As a result one hundred questionnaires were sent to teachers in group one, two hundred to teachers in group two, and three hundred to teachers in group three.

In all, seven hundred twenty-one questionnaires were mailed.

RETURNS

To the questionnaires sent to the one hundred twenty-one "out-staters", one hundred forty-one responses were received. It may be concluded therefore that some of the "out-staters" had not been identified previously as having at one time or another taught in states other than New York.

To the questionnaires sent to the six hundred "in-staters", three hundred sixteen responses were received. In all, four hundred fifty-seven questionnaires were returned. Twenty-one of the questionnaires were not usable for several reasons. In some cases, the items were not checked because the respondents did not teach Regents' courses in science. In other cases the schools in which the respondents taught did not offer the Regents' Examinations but rather used the College Entrance Board Examinations. Some were returned to the sender because the location of the addressee was unknown.

TABULATION OF REPLIES

It was decided to tabulate the data from the sections of the questionnaire according to the various questions found in each section. The tabulations follow: *

I

PERSONAL DATA

A. How many years have you been teaching in New York State?

The respondents who were "out-staters" indicated a length of service ranging from one to ten years; the "in-staters", from one to forty-two years.

* Percentages in the following tables are based on the total number of returns. Since all respondents did not in all cases answer all questions, total percentages may not always equal one hundred percent.

TABLE I

B. What Regents' courses in science have you taught in New York State?

Course	Number of Out-staters	Number of In-staters
General Biology	106	235
Chemistry	110	258
Physics	100	244
Earth Science	30	64

Table I indicates that the greatest number of Out-staters and In-staters had taught chemistry, the smallest number of both groups taught earth science.

TABLE II

C. What Regents' courses are you now teaching in New York State?

Course	Number of Out-staters	Number of In-staters
General Biology	65	281
Chemistry	80	192
Physics	63	176
Earth Science	8	21

Table II indicates that the greatest number of the Out-staters are now teaching chemistry and the greatest number of the In-staters are teaching biology. The smallest percentage of both groups are now teaching earth science.

D. How many years have you taught science courses in states other than New York?

The Out-staters claimed to have taught from one to ten years in other states.

E. Please indicate the states in which you have taught science other than New York.

The Out-staters came to New York after teaching science in thirty-five of the forty-eight states, as well as in Hawaii, Puerto Rico, Canada, and in the United States Army Air Force.

F. What courses in science have you taught in these other states?

The courses other than the "standard" Regents' courses in science taught by Out-staters were as follows:

Aeronautics	Hygiene
Agriculture	Meteorology
Anatomy	Nature Study
Aviation	Physiology
Botany	Radio
Consumer Science	Related Vocational Science
Geography	Zoology
Health	

II

Teachers Opinions of the Regents' Examinations in Science

TABLE III

A. To what extent do the Regents' measure the topics listed in the present corresponding syllabus?

Rating	Out-staters Number	Out-staters Percent	In-staters Number	In-staters Percent
Very Well	53	37.5	127	40
Fairly Well	78	55.3	178	56.3
Poorly	7	4.9	10	2

Table III indicates that the greatest percentage of both Out-staters and In-staters believes that the examinations measure fairly well to very well the topics listed in the corresponding syllabi.

TABLE IV

B. To what extent do the Regents' measure the achievement of the student accurately?

Rating	Out-staters Number	Out-staters Percent	In-staters Number	In-staters Percent
Very Well	20	14	62	19.6
Fairly Well	86	60.9	185	58.5
Poorly	34	24	60	19

Table IV indicates that the greatest percentage of both Out-staters and In-staters believes that the examinations measure the student achievement fairly well.

TABLE V

C. To what extent do the Regents' measure subject matter desirable for college entrance?

Rating	Out-staters Number	Out-staters Percent	In-staters Number	In-staters Percent
Very Well	58	41	148	48.6
Fairly Well	90	63.8	130	41.1
Poorly	13	9.2	18	5.7

Table V indicates that the greatest percentage of the Out-staters believes that the Regents' measure the subject matter desirable for college entrance fairly well while the greatest percentage of the In-staters believe that they measure it very well.

TABLE VI

D. To what extent do the Regents' measure subject matter desirable for non-college students who are headed for the farm or technical industries?

Rating	Out-staters Number	Out-staters Percent	In-staters Number	In-staters Percent
Very Well	7	4.9	18	5.7
Fairly Well	46	32.8	101	32
Poorly	93	66	192	60.5

Table VI indicates that the greatest percentage of both Out-staters and In-staters believes that the Regents' measure poorly subject matter desirable for non-college students who are headed for the farm or technical industries.

TABLE VII

E. To what extent do the Regents' measure subject matter desirable for the general cultural development of non-college, non-technical pupils?

Rating	Out-staters Number	Out-staters Percent	In-staters Number	In-staters Percent
Very Well	10	7.1	35	11.0
Fairly Well	67	47.5	121	38.3
Poorly	66	46.3	158	50.0

Table VII indicates that both Out-staters and In-staters agree that in general the Regents' measure fairly well to poorly subject matter desirable for the general cultural development of the non-college, non-technical pupils.

TABLE VIII

F. To what extent do the Regents' emphasize facts rather than understandings of science?

Opinion	Out-staters Number	Out-staters Percent	In-staters Number	In-staters Percent
Yes	90	63.8	186	58.9
No	34	24.5	92	29.1
No opinion	11	7.8	28	8.9

Table VIII indicates that the greatest percentage of both groups believes that the Regents' emphasize facts rather than understandings of science.

III

TABLE IX

Please indicate the extent to which the Regents' examinations in science emphasize the following objectives.

Table for Out-staters

Objectives	Too Much No.	Too Much %	Desirable No.	Desirable %	Too Little No.	Too Little %
Facts	77	54.6	62	43.8	1	0.7
Understanding of Scientific Principles	2	1.4	80	56.7	59	41.8

TABLE IX—Continued

Objectives	Too Much No.	Too Much %	Desirable No.	Desirable %	Too Little No.	Too Little %
Development of Scientific Attitudes	0	0.0	52	36.9	90	63.8
Development of Skills In the Scientific Method	2	1.4	44	31.1	96	68.01

Table IX indicates that the greatest percentage of Out-staters believes that the Regents' give too much emphasis to facts, desirable emphasis to understanding of scientific principles; but too little emphasis to development of scientific attitudes and development of skills in the scientific method.

TABLE X

Please indicate the extent to which the Regents' examinations in science emphasize the following objectives.

Table for In-staters

Objectives	Too Much No.	Too Much %	Desirable No.	Desirable %	Too Little No.	Too Little %
Facts	158	50.0	149	47.3	1	0.3
Understanding of Scientific Principles	3	0.9	191	60.6	115	36.5
Development of Scientific Attitudes	3	0.9	122	38.7	182	57.6
Development of Skills in the Scientific Method	3	0.9	106	33.5	194	61.5

Table X indicates that the greatest percentage of In-staters believes that the Regents' give too much emphasis to facts, desirable emphasis to understanding of scientific principles; and too little emphasis to development of scientific attitudes and development of skills in the scientific method.

IV

TABLE XI

A. Do teachers teach for the Regents'?

Opinion	Out-staters Number	Out-staters Percent	In-staters Number	In-staters Percent
Yes	131	93.0	289	91.5
No	5	3.7	17	5.4
No opinion	3	2.1	3	0.9

Table XI indicates that the greatest percentage of both groups believes that teachers teach for the Regents'.

TABLE XII

B. Do students work to pass the Regents' instead of learning science?

Opinion	Out-staters Number	Out-staters Percent	In-staters Number	In-staters Percent
Yes	115	81.6	241	76.4
No	11	7.8	61	19.3
No opinion	5	3.7	4	1.2

Table XII indicates that the greatest percentage of both groups believes that the students work to pass the Regents' instead of learning science.

TABLE XIII

C. To what extent do the Regents' serve as a valuable measuring device for these types of students?

Table for Out-staters

Type of Student	Yes No.	Yes %	No No.	No %	No Opinion No.	No Opinion %
Above average student	83	58.7	53	37.6	1	0.7
Average student	77	54.5	53	37.6	10	7.1
Below average student	18	12.7	110	78.1	6	4.2

Table XIII indicates that the greatest percentage of Out-staters believes that the Regents' are a valuable measuring device for the average and above average student, but a poor one for the below average student.

TABLE XIV

Table for In-staters

Type of Student	Yes No.	Yes %	No No.	No %	No Opinion No.	No Opinion %
Above average student	204	64.5	112	35.5	9	2.8
Average student	195	61.8	101	32.0	17	5.4
Below average student	57	18.0	230	72.8	18	5.7

Table XIV indicates that the greatest percentage of In-staters believes that the Regents' are a valuable measuring device chiefly for the average and above average student.

TABLE XV

D. Do you believe that science courses you taught Out-state are more practical than those you taught In-state?

Opinions	Out-staters Number	Out-staters Percent	In-staters Number	In-staters Percent
Yes	65	46.0	5	1.6
No	60	42.5	1	0.3
No opinion	11	7.8	98	31.0

Table XV fails to indicate that the Out-staters as a group have a definite opinion as to the greater practicality of the science courses that they taught in states other than New York.

TABLE XVI

E. Do you believe that the Regents' restrict you in what you would like to teach?

	Out-staters		In-staters	
Opinions	Number	Per-cent	Number	Per-cent
Yes	98	69.5	1	0.3
No	38	26.9	98	31.0
No opinion	2	1.4	6	1.9

Table XVI indicates that the greatest percentage of the Out-staters believes that the Regents' restrict them in what they would like to teach. The greatest percentage of In-staters' responses believes that they are not restricted in their teaching.

TABLE XVII

F. How do you believe that students in New York State compare with those in other states in achieving the following objectives?

Table for Out-staters

Objectives	Greater achievement than Students in other states		About the same achievement		Less achievement	
	No.	%	No.	%	No.	%
Facts	70	49.6	50	35.4	5	3.7
Understanding of Scientific Principles	25	17.7	74	52.5	24	17.0
Development of Scientific Attitudes	16	11.6	66	46.7	39	27.6
Development of Skills In the Scientific Method	18	12.7	64	45.4	40	28.2

Table XVII indicates that the greatest percentage of Out-staters believes that the students of New York State as compared with those in other states have greater achievement in facts and about the same achievement with respect to understanding of scientific principles, development of scientific attitudes and development of skills in the scientific method.

TABLE XVIII

Table for In-staters

Objectives	Greater achievement than Students in other states		About the same achievement		Less achievement	
	No.	%	No.	%	No.	%
Facts	79	25.0	61	19.3	3	0.9
Understanding of Scientific Principles	34	10.7	88	27.8	21	6.6
Development of Scientific Attitudes	24	7.6	82	25.9	33	10.4
Development of Skills In the Scientific Method	23	7.3	82	25.9	34	10.7

Table XVIII indicates that the In-staters who checked this question more or less agreed with the opinions of the Out-staters as indicated in Table XVII.

TABLE XIX

G. What will abolition of the Regents' do to standards of teaching science?

	Out-staters		In-staters	
Rating	Number	Per-cent	Number	Per-cent
Lower standards	72	51.0	170	54.0
No change	36	25.5	70	22.0
Raise standards	27	19.2	53	16.7

Table XIX indicates that the greatest percentage of both groups believes that the abolition of the Regents' would result in lowering the standards of science teaching in New York State.

V

TABLE XX

What shall be done in the future with respect to the Regents' Examinations in Science?

	Out-staters		In-staters	
Opinions	Number	Per-cent	Number	Per-cent
Should be discarded	18	12.8	29	9.2
Should be retained as is	20	14.2	52	16.4
Should be retained but modified	49	34.8	124	39.3
Should be abolished as graduation tests but retained in modified form as a tool to discover weak spots in curriculum or teaching	55	39.0	108	34.2

Table XX indicates that of both the groups only 10.3% wish to abolish the Regents'.

VI

Please indicate briefly what should be done to improve the quality of the Regents' Examinations in Science assuming that they are retained.

Opinions with respect to desirable changes in the Regents' Examinations in Science are found later.

VII

TABLE XXI

If the Regents' Examinations were modified as you suggested in VI, would you approve of their retention?

	Out-staters		In-staters	
Opinion	Number	Per-cent	Number	Per-cent
Yes	83	58.9	196	62.1
No	16	11.3	27	8.5
No opinion	12	8.5	20	6.3

Table XXI indicates the greatest percentage of both groups would approve of the retention of the Regents' if suggested changes were made.

VIII

MISCELLANEOUS ITEMS

TABLE XXII

A. Should a scoring key be provided?

	Out-staters		In-staters	
Opinion	Number	Per-cent	Number	Per-cent
Yes	85	60.3	222	70.2
No	39	27.6	72	22.7
No opinion	10	7.1	10	3.1

Table XXII indicates that the greatest percentage of both groups believes that a scoring key should be provided.

TABLE XXIII

B. Should the teachers "passing percentage" be reported to the state?

	Out-staters		In-staters	
Opinion	Number	Per-cent	Number	Per-cent
Yes	13	9.2	41	12.9
No	108	76.8	230	73.0
No opinion	15	10.6	33	10.4

Table XXIII indicates that the greatest percentage of both groups believes that the teacher's "passing percentage" should not be reported to the state.

TABLE XXIV

C. Do you approve of the state rechecking papers for correct scoring?

	Out-staters		In-staters	
Opinion	Number	Per-cent	Number	Per-cent
Yes	86	61.0	207	65.6
No	29	20.5	58	18.3
No opinion	20	14.3	37	11.7

Table XXIV indicates that the greatest percentage of both groups believes that the state should recheck the examinations for correct scoring.

TABLE XXV

D. What is your opinion concerning the disposition of each teachers papers?

	Out-staters		In-staters	
Disposition	Number	Per-cent	Number	Per-cent
Retained in the school as the property of the school	17	12.1	36	11.4
Retained in the school but subject to call by the State	56	39.7	141	44.7
Forwarded to the State for disposition	56	39.7	137	43.5

Table XXV indicates that there is considerable diversity of opinion concerning the disposition of the papers.

COMMENTS TO THE QUESTIONNAIRE

The comments found on the questionnaires were too numerous and varied to include all of them. However, those that are listed herein are representative of those that were made. The wording, wherever possible, is the same as that of the respondent.

Comments on Question VI: Opinions with respect to changes on Regents' if they are retained.

1. Need more explicit scoring instructions.
2. Questions which require considerable thinking should be grouped to point to exceptional students.
3. Part II of the examination should cover each phase of the subject.
4. Examinations should be developed to measure scientific attitudes, scientific principles and skills in the scientific method with application of the same.
5. Avoid verbage—be explicit.

6. Part I of the examination is too factual.
7. Examinations should be brought up-to-date with relationship between the student and everyday life.
8. Do away with the occasional trick questions.
9. In Part I there is too much stress on terminology for the average and below average students.
10. A question may have two answers *but* the Regents' accept only one.
11. Regents' should offer three types of examinations:
    a. One for Regents' credit and college entrance.
    b. One for non-Regents' credit but for graduation credit.
    c. One for achievement to those who fail (a) or (b).
12. It would be better to have a greater choice of questions in the second part of the examination with greater credit assigned to each question part.
13. There should be a table of density, specific gravity, etc., given the student instead of always giving the information for individual questions. This acts as a hint as to how the problem is worked.
14. The fear of dismissal on account of having pupils fail the Regents' should be removed from the teachers if anything worthwhile is to be achieved by teachers.
15. A two level program should be initiated. We are completely neglecting the competent youngsters.
16. They should be machine scored.
17. Daily work should be credited, at least two-thirds of the final mark. This would definitely set a higher standard and incite students to work consistently throughtout the year—results scholarship.
18. The form of the examination should be changed from time to time.
19. The examinations should be graded on a curve basis to compensate for varying degrees of difficulty in consecutive tests. Abolish the arbitrary passing grade of 65%.
20. Diagrams give a good insight as to the pupils knowledge of science—especially in physics and chemistry.
21. Have a wider range of questions from a larger Examinations Committee. Invite all science teachers to submit questions in fields they teach for considerations of the Committee.
22. In physics and biology there should be more specific questions on Part II of the examinations.

Comments on Question IX: General opinions and comments.

A. *Comments Favorable to the Regents' Examinations in Science.*

1. They provide a wonderful incentive to the the teacher.
2. As a universal measuring stick they cannot be beat.
3. Students are rated on a state wide basis.
4. From what is known about the testing that the individual teachers can do, we cannot afford to give up the Regents'.
5. Regents' have one big value—to keep you and the class on a course of study. Without them, some part of these very broad and generalized courses would be neglected, particularly with very dull or very bright groups.
6. The Regents' sort of keep us in line so we don't stray too far afield like all of us like to do.
7. They give the student a break.
8. Eliminating the Regents' will result in a general lowering of standards. Teachers will become lax and will teach only what interests them or what is easier to teach. The present Regents' tend to keep the teachers on the ball.
9. The Regents' are all right. The problem is not a Regents' problem but a teachers' problem.
10. These Regents' Examinations do set up a very excellent standard and maintain it. A standard is necessary, for pupils and teachers. A high standard is more important today than ever before.
11. The present examinations suit me fine—since I have found nothing which checks Science Education as well.
12. Personally I like teaching a Regents' course and try to teach the course for its own sake and not to pass Regents'. I do have review classes and do old Regents' Examinations, but I feel an examination made out by other people—experts in the field—and not known by pupils or teachers ahead of time is a challenge and is good training. Regents' Examinations do provide uniformity for basic information in each course. However, there could be improvement in examinations. Some years the examination is easier and then a change in the group brings an examination that is difficult. A scoring key would provide uniformity in results for comparison and make the results more valid and would aid new teachers.

B. *Comments Unfavorable to the Regents Examinations in Science.*

1. They are too easy and favor the poorer students.
2. The Regents' hamper good teaching.
3. They make the teacher spend 6–8 weeks drilling their students so they can pass them.
4. They are not up-to-date.
5. They are a left over from ancient times.
6. They place all students in the same pattern.
7. They are unjust to the average student that works hard all year long and then if he cannot pass the Regents' he loses a whole year's work and credit.

8. The Regents' should be discarded in that they tend to restrict the field or area, and they tend to make both the teacher and student point toward accomplishment in the examination grade.
9. They are millstones around the necks of teachers. They constitute bureaucracy in the worst form.
10. Let's get the Regents' Examinations abolished before more harm is done—and soon.
11. All they do is test the power of memory of the student for factual knowledge.
12. They never are up-to-date, they are always several years behind current developments in science.
13. They are a barrier to true education. They hold down the teacher and the student. They are particularly destructive when a school is in the hand of incompetent, unprofessional administrators.
14. The Regents' Examinations have had their day. This is the era of College Entrance and College Board Examinations, too much has been made of pupils receiving a Regents' diploma.
15. If a student's credit in a science course depends only on an examination—why keep any records of daily class work, tests and so on? Why should an examination alone be used as the sole criteria for graduation of our high school boys and girls?

CONCLUSIONS AND RECOMMENDATIONS

In so far as the techniques employed in this study may be valid the following conclusions seem justified:

1. It is known that for all the science courses investigated in this study syllabi are available. Apparently teachers are satisfied that, if the courses are taught in accord with the outline of the syllabi, the examinations prepared for those courses are likely to be reasonable. (Tables III and IV).

2. Teachers believe that the Regents' are better devices for evaluating the achievement of college-entrance students than that of the non-college students who are headed for the farm or technical industries, or for that matter for the non-college student who takes science for its general cultural value. (Tables V, VI, and VII).

3. Teachers are of the opinion that the Regents' examinations are better measures of factual achievement than of understanding of science. (Tables VIII, IX, and X). This in and of itself would seem to indicate that the examinations place emphasis on only one of the four major objectives of the teaching of science.

4. The data in Tables XI and XII indicate both teachers and students tend to be more concerned with the students passing of the Regents' examinations than with the students learning about science.

5. In spite of certain criticisms that have been voiced in the State, the teachers of science believe that the examinations are good measuring devices for the majority of students. (Tables XIII and XIV).

6. In spite of criticisms that have been voiced in the State that the Regents' restrict teachers in what they would like to teach, the majority of Out-staters expressed no positive belief that the science courses they taught in other states were more practical than those they were teaching in New York State at the time of this study. (Tables XV and XVI).

7. In general, a majority of In-staters indicated that they did not believe the Regents' system restricted them in what they wished to teach. (Table XVI).

8. In spite of certain criticisms to the contrary the teachers polled in this study believed that the students of New York State attain the same or a higher level of achievement than students in other states, in so far as the major objectives of the teaching of science are concerned. (Tables XVII and XVIII).

9. The data in Table XIX, indicate that more than half of the teachers believe that the abolition of the Regents' examinations will reduce the standards of science teaching in the State of New York. About another quarter believe that the abolition will produce no change in standards. The rest of the respondents to the question believed that standards would be raised by this abolition.

10. The data in Table XX, indicate that nearly ninety percent of the teachers wish to retain the Regents' examination although a little more than two thirds believed that their construction and use might well be modified. Only ten percent believe that they should be discarded.

11. The data in Table XXI indicate that if the examinations were modified according to the suggestions made by the respondents, more than two-thirds would approve their retention. The rest of the respondents expressed no opinions, since many of them made no suggestions for modifications.

12. About two-thirds of the respondents expressed the desire that a scoring key be provided with the respective examinations. (Table XXII).

13. The data in Table XXIII indicate that over three-fourths of the teachers believe that the teachers passing percentage should not be reported to the State. This is in accord with present policy although many believe erroneously that the State keeps such records.

14. The data in Table XXIV indicate that nearly two-thirds of the teachers desire that the State recheck a sampling of the papers that the teachers have scored and forwarded to the State. About one-third expressed themselves against such a policy.

15. The data in Table XXV indicate that nearly four-fifths of the teachers believe that the examinations should be subject to the call of the State. About one-half of these would keep the papers in the school unless they were called for.

In so far as the conclusions may be defensible, the following recommendations seem reasonable:

1. Despite comments from certain quarters, it is doubtful whether the teachers who are actually using the Regents' Examinations are as vehement against their use as some persons would indicate. It may be desirable then for such critics to confer with a greater number of teachers before they express opinions which these research findings fail to substantiate.

2. There is some doubt as to whether the standards of teaching would be raised if the Regents' were abolished and the teachers were allowed to develop their own final examinations. Hence it is suggested that a special committee be formed to examine the extent to which the Regents' examinations in science may be improved by including questions that measure objectives other than factual achievement. Such objectives would include understandings of scientific principles, development of scientific attitudes, and development of skills in the scientific method.

3. Despite opinions expressed to the contrary the teachers in general do not believe they are restricted in their teaching. It is suggested therefore, that where persons indicate that they are restricted, that a program be established to show such teachers how to modify courses in such a way that the feeling of restriction may be abolished.

4. There should be provided for each teacher a scoring key for use with the examinations. The recommendation has been adopted already by the State and the keys are now available for questions on Parts I of the examination.

5. In order to retain the value of the examinations it is suggested strongly that no effort be made to use them as devices for evaluating teachers. Thus "passing percentages" should never be reported.

6. It seems desirable also that the State continue to check a sampling of papers for correct scoring.

7. It should be stated here that, although it is evident that the attitudes of the teachers toward the Regents' examinations are far more complimentary than has been expressed or supposed, the examinations themselves be evaluated for their reliability and validity. These determinations should then be compared with determinations of reliability and validity of teacher-made examinations. Thus, positive evidence may be obtained for determining their real value.

8. In summary, there seems to be no real reason, at least as far as teachers attitudes are concerned, for abolishing the Regents' Examinations in Science.

REPORT OF THE THIRTIETH CONFERENCE ON THE EDUCATION OF TEACHERS IN SCIENCE

Report prepared by WILLARD JACOBSON

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The Thirtieth Conference on the Education of Teachers in Science took a look at some of the problems and accomplishments of past years and then considered the future possibilities for the Conference.* One of the highlights of the Conference was the testimonial dinner for Dr. S. R. Powers who, throughout the years, has been one of the men responsible for its continued success. Dr. Powers, in his address, reviewed the progress that has been made and suggested new directions for possible action. The Conference as a whole followed this theme, and took decisive steps for the future.

Two new regional sections were organized as follows:

1. Midwest Section: Professor G. P. Cahoon, Ohio State University, Vice President.
2. Southern Section: Professor Ward Fletcher, University of Florida, Vice President.

Professor Katherine Hill of New York University was elected Vice President of the Eastern Section. Professor Willard Jacobson of Teachers College was elected Permanent Secretary and Treasurer, a new office established at this meeting. An executive committee in charge of overall planning was reconstituted. This committee is in charge of planning the Conference programs. It is composed of the President, Vice Presidents, Secretary and Treasurer, one elected representative from each of the three regional sections and one Teachers College representative. The annual Fall meeting is scheduled to be held at Teachers College, Columbia University. The spring meetings will be regional, and each section is tentatively planning to hold a meeting at some institution in their region.

Again, the activities of the Conference were, to a large extent, centered in the various discussion groups that met, discussed problems and planned for the future. The following are brief reports from each of the groups.

Study Group I. Science in the Elementary School.

Chairman: Katherine Hill, New York University, New York.

Recorder: W. E. Merrill, Radford College, Virginia.

The discussions in the elementary group were focused on two major problems:

1. How can we help teachers, both those who have studied science in college and those who have not, to use more science in their teaching in the elementary school?
2. What problems do we need to tackle in relation to teacher education?

When discussing the problems that should be tackled in relation to the education of elementary teachers, emphasis was placed on the value of having teachers who are capable in science as well as the whole elementary school program. Such teachers would be able to make time for science and to integrate it with the other subjects. In order to carry out the science part of the elementary school program teachers should know how to work with simple and inexpensive materials, preferably those materials that children can find at home and use there. Teachers should be willing to move along with children in their learning by being sensitive to the possibilities for learning and by allowing children time to think.

Unfortunately, many teachers in the field are afraid to do much science in the school. These teachers can find a vast amount of material in the community in which they work and these materials can become the

* The Thirty-first Conference on *The Education of Teachers in Science* will be held at Teachers College November 13, 14, and 15. The Conference theme will be "Science in the General Education of Children and Young People."

center of science experiences for children. Often times the mere suggestion of the availability of a particular object will cause many children to hunt and to explore for themselves. This exploration can be focused on the practical and useful aspects of the community resources.

The pre-service workshop or camping program for teachers was described as a means of getting teachers to see the possibilities of science instruction and the uses of available materials. In some localities, colleges are cooperating with the public school systems in putting on these workshops. The colleges often send instructors to help with the program and then allow the teachers to apply the workshop credit toward a degree. The real purpose of the workshop is to help teachers learn more about working with children, and to help teachers find out how problems originate, and how these problems can be brought out and solved. This type of study is very valuable in connection with the science program in that it gets to the center of many of the difficulties in the teaching of science in the elementary school.

Study Group II. Science in the Junior High School.

Chairman: Paul Brandwein, Forest Hills High School and Teachers College, Columbia University.

Recorder: Willard Jacobson, Teachers College, Columbia University.

The group discussions were centered upon specific methods and techniques which can be used to deal with problems that arise in teaching situations.

How can we prepare ourselves to teach youngsters from other cultures? The group made a strong recommendation that youngsters from other cultures should not be segregated into separate groups. Instead, they should be helped to become useful members of the regular groups or classes in the school. This may be done in several ways. Class members who speak both English and the language of the youngster from another land should be enlisted in this process. In some cases, this process may resemble the "Big Brother" movement. These bilingual youngsters may become guides and friends who help youngsters from other lands make their adjustments in a new culture. These youngsters from other cultures are important assets to a classroom group. Everyone benefits as these youngsters learn to enrich classroom discussion by bringing in the insights and ideas that arise from their unique experiences.

How can we prepare ourselves to work with youngsters who have very little interest in school or school activities? We soon found that we were not discussing youngsters that were *atypical.* Instead, these youngsters are *atraditional.* Their needs and desires cannot be met within the rigid framework of our traditional school. A new framework must be found in which these youngsters can find something rewarding and worthwhile.

How can this be done? Several suggestions were considered. We should allow the youngsters to talk and discuss. It is when they have this freedom of self-expression that students and teacher can talk about things that mean something to each of them. Certainly, this requires security on the part of the teacher, but what youngsters have to say may often be much more important than our more academic pronunciamentos. If the discussion becomes too heated, why not hold a thermometer in front of the class to measure the temperature of the discussion. One teacher reported that this simple gesture was usually conducive to rapid cooling.

The teacher should know as much as possible about the students. Certainly, investigate and study, but "take with a grain of salt" their previous records. The teacher should make wise use of such techniques as open-ended questions and the Mooney Problem Check List. He should be interested in their plans for the future. What do they like to do after school? What would they like to do in high school, college and after? What do they hope to

make of their life work? The teacher should discuss with them what they would like to do in their class. Although it seems to be a neglected attribute, we should be unequivocally honest with young people. If there is some reason why we cannot do something, we should make those reasons explicit. We should tell them why we can't.

The teacher should help youngsters to realize and feel that they are important. They should assume responsibility. To do this they will use the many resources that they have. The youngster who speaks both Spanish and English is in an excellent position to tutor and help a fellow student who speaks only Spanish. Also, youngsters will gain a feeling of importance and self-respect as we treat them with respect. This may be simple, yet difficult. It means, for instance, that we must listen when they have something to say. It means that we should not read our correspondence or sign slips of red tape when they are talking to us. They have a right to the same respect we expect.

There are other means by which we can help youngsters to recognize their importance. We should try to have a rich enough program to fit the needs and interests of every youngster in the group. How? It was suggested that we must place considerable emphasis upon individual's hobbies. There must be room and encouragement of both individual and group projects. The teacher may have laboratory assistants. In some cases, it was suggested that these assistants might be elected by the members of the class. It was also suggested that we should work with youngsters in coping with some community problems for which they will be recognized by the adults in the community. In one example that was cited, a class tested all the soil in the potential victory gardens in the community during the war.

As our discussion drew to a close, our chairman suggested that, perhaps, we teachers, instead of the youngsters, were atypical. The youngsters with whom we work are typical of and living in the world of our times. It is our job to live and work with them for a better world.

Study Group III. Teacher Education Problems and New Development in the Biological Sciences.

Chairman: Joseph H. Zipper, Gannon College, Erie, Pennsylvania.

Recorder: Matthew J. Brennan, State Teachers College, Jersey City, New Jersey.

Does the present program of biological science training for teachers prepare them to offer courses designed to meet the needs of the citizen in our modern democratic society?

In order to answer this basic question it is necessary to define the problem areas which now exist and are expected to arise in the immediate future.

The American Association of School Administrators in its 1951 yearbook *"Conservation Education in American Education"* has recommended the inclusion of conservation as an integral part of the school program. To implement the recommendation of this group the National Association of Biology Teachers has undertaken a 3 year study designed to set up a program of conservation. As a result teacher training institutions and science educators in particular are faced with the problem of integrating into their curriculum problem areas which will acquaint every prospective teacher with the scientific, social, and economic aspects of the problem.

The subject of conservation fulfills to the greatest possible extent the goals of general education. Although the biology teacher will be faced with the brunt of the job in any conservation program, there must be integration of his efforts with the members of the science department and other departments as well. The pH of soils may be covered in chemistry, minerals in the physical science course and the economic and social implications of conservation by the social studies department. Never has a subject offered such possibilities for putting into practice the inte-

gration of purpose and effort which has been advocated in general education.

It is anticipated that implementation of such an integrated program of education must overcome the common fear of the subject matter specialist that content must be sacrificed in any attempt to meet a problem situation which arises. Teachers as a group do not feel confident to deal with frictional areas such as conservation or other community problems. Their sole reliance is on their textbook. Recent studies indicate that present textbooks in the field of science give inadequate treatment to the conservation and intelligent use of our natural resources. As a result, the subject has been generally neglected.

Changes in the nature of our school population and in the basic concepts of the teaching-learning process necessitate not only a general education for biology teachers but also general education in biology. Science teachers must integrate the subject matter of their courses with the experiences of life if their instruction is to be meaningful. For, subject matter takes on meaning only as it relates to our experience. There are available to us as science teachers vast areas of knowledge. How can we use it to solve every day problems of living? Are we as teachers making use of the information available to us? The answer to these questions may help us as science teachers to narrow the existing gap between scientific discoveries and use of these findings for the benefit of the present day community.

Our study group made the following recommendations:

1. The vast amount of scientific knowledge available to the biology teacher dictates a wise choice in the materials which will receive emphasis in a program of general education. Teacher education institutions must reorient their emphasis in the direction of functional problem areas such as conservation, public health, and narcotics. We must give less attention to the anatomy of the clam and more attention to the effects of the pollution of our coastal waters on the shellfish industry.

2. Biology teachers must receive a broad general education, plus a general education in biology.

3. To insure a more integrated training in science education, there should be at least one science educator in every teacher education institution to integrate the subject matters of the various departments.

4. To be more effective, biology teachers must realize that biology is only a part of general education. To be more meaningful the subject matter of biology must be fitted to the direct experiences of their students.

5. We recommend that the subject of conservation be made an integral part of the teacher education program and that the area of resource use and conservation be taught by the integrated curriculum method involving the cooperation of all school departments rather than by a single course of study.

6. We feel that science teachers must accept the challenge which administrators have issued to them. It is their duty to assure that the youth of our nation receive the facts of conservation.

7. We further feel that the topic of conservation is worthy of consideration as a central theme for our next conference.

Study Group IV. Physical Sciences.
Chairman: Harry H. Williams—Horace Mann School.
Recorder: Elsa M. Meder — Houghton Mifflin Company.

The discussion of the physical sciences study group had four foci: (1) the problems of developing physical-science courses in high schools, (2) the problems of improving existing physics and chemistry courses, (3) the problems of identifying the values to be gained from courses in the physical sciences; and (4) the problems of up-grading teacher status.

(1) The development of a course in the physical sciences analogous to the biology course which developed from botany and

zoology has been receiving attention for the past ten years, and may be expected to continue to be an area of interest to many teachers. Relatively few schools have such courses today, and in the places where they do exist, the courses often consist of relatively discrete units of astronomy, geology, physics, and chemistry. This situation may be attributed in part to the specialized competence of the teachers who develop such courses, in part to the demands on the teacher's time; and in part, perhaps, to inertia and to lack of imagination. Improvement may be expected as teachers become more adept in organizing their teaching in terms of people's problems.

(2) The improvement of existing courses in chemistry and physics may be hoped for, too, as teachers learn to organize teaching around the concerns of people. Physics and chemistry, like any other course, may be seen as a start toward the achievement of values significant in the lives of human beings. To be sure, there is resistance to change here as elsewhere, and the excuse of Regents, college requirements, and syllabi are often given by those who feel bound to tradition. Yet examinations and courses of study can be helps as well as hindrances, and advances are more likely to be achieved by working within an existing framework, than by hewing away at that framework. It is better not to tear down our barns until we have built the greater barns.

(3) If education in the physical sciences is to be improved, those who are responsible for such education must have a conviction of the importance of these sciences, and that conviction comes from identifying the values of the courses to the students. One point of view expressed in the group was that science educators should study how people's lives are affected by science, and how young people of today are different from those of yesterday as a result of such technological advances as television. Another point of view was to the effect that study of the physical sciences is important as it helps young people develop an understanding of the nature of the physical universe, and of how such knowledge has been gained and is being extended.

(4) But whether the viewpoint be primarily sociological or philosophical, the identification of values calls for considerable thought on the part of teachers, and requires unrelenting effort. The basic problem of teacher education is the preparation of teachers who can and want to give such thought and effort to their jobs. Even more basic is the problem of attracting to the teaching profession a suitable number of people able and willing to work devotedly toward these ends. This problem will not be solved merely by increasing teachers salaries; its solution is more largely a matter "of selling society on the importance of having top-flight teachers in the schools." This is no easy task. Coincident with the improvement of teachers salaries have come the recent vicious attacks on public education. Yet these, ugly and venomous though they may be, may yet be found to be the bearers of a precious jewel, for at least they provide an opportunity for bringing about understanding of the function of education and the importance of the teaching profession.

Study Group V. College Sciences.

Chairman: G. P. Cahoon, Ohio State University.

Recorder: R. W. Gifford, Iowa State Teachers College.

The study group on the college sciences centered its attention on general education. As the issues were sharpened, the discussion focused on science in the general education aspects of teacher preparation. There was agreement on certain aspects of the science program in general education. We want students to work with science subject matter, but, perhaps, in a different way. We want them to learn to use resources from all fields in finding solutions to basic problems. We want the class to help select the problems, and to depart from our classes with a thirst for more knowledge

and a sensitivity to the social implications of science.

Various problems were raised in the discussion. What is good education for science teachers? How should courses be varied for science majors and for non-majors? Is there some definite subject matter that should be covered in a general education science program? What criteria should be used for the selection of problems to be dealt with in a general education science program? How can we prepare teachers to teach in this type of program?

College catalogs show that some changes are taking place in philosophy, curriculum and methodology. We have, perhaps, developed a philosophical base; the next steps should be in terms of developments in curriculum and methodology. The conference should advocate and encourage the development of experimental approaches to science in the general education program.

PREVALENCE OF BELIEF IN SCIENCE MISCONCEPTIONS AMONG A GROUP OF IN-SERVICE TEACHERS IN GEORGIA *

W. W. E. BLANCHET

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STATEMENT OF THE PROBLEM

THE purpose of this investigation was to find out the prevalence of belief in certain popular science misconceptions among a group of in-service teachers in the common schools for Negroes in Georgia.

TECHNIQUES EMPLOYED

One hundred popular science misconceptions were used in this study. They were those that had been compiled by Hancock [1] and judged by a group of 53 experienced teachers to be the most important ones, of a list of 292 misconceptions, in terms of their potentialities for affecting the behavior of a person subservient to them. As a result of the statistical techniques that Hancock used in his study, the 100 science misconceptions were arranged in descending order of importance as shown by the composite evaluation of the 53 science teachers.

A group of 318 in-service teachers who were attending the summer quarter at The Fort Valley State College, Fort Valley, Georgia, was included in this study. The group of in-service teachers consisted of those who had the equivalent of from one to eleven quarters of college work and those who were expecting to complete requirements for bachelor's degrees at the end of the summer quarter.

The 100 science misconceptions were formulated into a true-false test that consisted of the 100 statements of Hancock's list. That test with the following directions was administered to the 318 in-service teachers:

> Place a (T) for true in the parentheses after the statements below that you believe are true and an (F) after those that you believe are false. If you cannot place a (T) or an (F) after a statement because you do not understand a word or an expression in that statement, kindly underscore the word or expression.

A tabulation was made of the number of responses of true and the number of responses of false for each misconception. Obviously, from the type of test that it was, all responses should have indicated that each statement was false because each of the 100 statements embodied the idea of a misconception. The percent of responses

* Paper presented at the National Association for Research in Science Teaching Meeting, Atlantic City, New Jersey, February 18, 1951.

[1] Cyril H. Hancock. "An Evaluation of Certain Popular Science Misconception," *Science Education* 24:208–213; April, 1940.

of true for each misconception was calculated. That was done by dividing the number of responses of true for each statement by the total number of responses for that statement. For example, 258 in-service teachers indicated that "The best treatment for weak arches is through the use of well fitted supports" was true, while 33 indicated that it was false. There was a total of 291 responses for that statement. The 258 responses of true divided by the total number of responses, 291, gave 88.65 percent. Of the 291 teachers responding to that statement, 88.65 percent of the group believe that the idea of the misconception embodied in it is true. Thus, the percent of responses of true for a misconception was assumed to represent the prevalance of belief in that particular misconception among the in-service teachers responding to it. After the percent of responses of true was calculated for each misconception, the 100 misconceptions were arranged in descending order of their percents of responses of true.

Table I shows the rank of each misconception in terms of prevalence of belief in it (column I), its rank in importance from Hancock's study (column II), the number of responses of true (column III) and the total number of responses (column IV) for it, and the percent of responses of true, or the prevalence of belief in it (column V).

TABLE I

THE RANKS IN THE PRESENT STUDY AND IN HANCOCK'S STUDY, THE NUMBER OF RESPONSES OF TRUE, THE TOTAL NUMBER OF RESPONSES, AND THE PERCENT OF RESPONSES OF TRUE FOR EACH OF THE SCIENCE MISCONCEPTIONS

Misconceptions	I	II	III	IV	V
* The best treatment for weak arches is through the use of well fitted supports.	1	73	258	291	88.65
Many drugs that act as specific cures for diseases have been discovered.	2	25.5	260	297	87.54
It is common practice to disinfect the air in a sick room or lavatory.	3	82	254	291	87.28
Hydrogen peroxide is an effective germ killer.	4	67.5	245	292	83.90
Information concerning the evils of tobacco and alcohol is usually based on sound scientific investigations.	5	74.5	241	291	82.81
Large amounts of cereal roughage should be included in the diet of all individuals.	6	49	242	295	82.03
A drowning person always rises to the surface three times before finally sinking.	7	96.5	222	285	77.89
All diseases are caused by tiny living things.	8	17.5	225	290	77.58
Highly advertised mineral waters have proved beneficial in the treatment of many diseases.	9	49	223	293	76.10
Any person can succeed in any task he undertakes if he has the determination and will power to do so.	10	63	226	297	76.09
Pressing the upper lip or placing a key or piece of ice at the back of the neck are good ways to stop nose bleed.	11	96.5	209	283	73.85
If water is brought to a boil it is sure to kill all bacteria.	12	3.5	221	303	72.93
(*A certain mouth wash*) is very effective for killing germs.	13	17.5	211	290	72.75
If a snake bite is sucked the venom will enter the blood stream through any sore in the mouth.	14	93.5	198	273	72.52
Insanity is sometimes caused by overstudy.	15	83	203	289	70.24
Ovaltine has special sleep producing powers.	16	84.5	190	278	68.34

* Table I is read thus: As a result of the procedure described "The best treatment for weak arches is through the use of well fitted supports" had a rank of 1 within the list of 100 misconceptions (Column I), a rank of 73 in importance in Hancock's study (Column II), 258 responses of true (Column III), a total of 291 responses (Column IV), and a percent of responses of true of 88.65 as an indication of prevalence of belief in it (Column V), etc.

Most bacteria are harmful to man.	17	15	199	295	67.45
Color blindness can be cured witn proper treatment.	18	100	176	267	65.91
If the cure for a disease is highly advertised, it usually indicates that scientists have discovered many important facts about the cure for the disease. (Example, Common cold)	19	29.5	193	293	65.87
Acquired characteristics can be transmitted from parent to offspring.	20	74.5	192	293	65.52
Syphilis can be inherited.	21	17.5	194	300	64.66
The best treatment for tuberculosis is plenty of fresh air and exercise.	22	49	181	299	60.53
Measles is most contagious when the skin breaks out.	23	87	117	194	60.30
Inoculations will prevent the common cold for most persons.	24	67.5	174	190	60.00
It is correct to feed a cold and starve a fever.	25	43	177	296	59.79
Masturbation will cause feeblemindedness.	26	87	140	245	57.14
There is considerable scientific evidence that even moderate smoking is very harmful to all persons.	27	80	166	294	56.46
A person suffering from tuberculosis always appears to be weak and run down.	28	53	161	296	54.39
The wearing of eyeglasses causes one to "get used" to them, hence we should put off using them as long as possible.	29	25.5	108	201	53.72
If cousins marry, the children will probably be defective.	30	80	155	290	53.44
An osteopath is a medical doctor (M.D.) who has specialized in the treatment of bone ailments.	31	56	101	189	53.43
Boils are caused by bad blood in the system.	32	80	151	285	52.98
Underweight children are always in ill health, or are undernourished.	33	59.5	157	298	52.68
Malnutrition means not getting enough food.	34	71	157	302	51.98
Malnourished children are seldom found in better class homes.	35	36.5	150	289	51.90
A mother can influence the character of her unborn child by her thoughts.	36	77	148	290	51.03
Freezing kills bacteria.	37	10	161	318	50.62
Certain toothpastes are effective germ killers.	38.5	33	151	300	50.33
Laxatives should be used by most persons at least once every month in order to clean out wastes that accumulate in the intestines during the month.	38.5	14	151	300	50.33
A scientific theory should be, and is, the absolute truth.	40	56	135	278	48.56
Syphilis is an advanced stage of gonorrhea.	41	71	139	297	46.80
If more heat is applied to boiling water the temperature goes higher.	42	65	137	297	46.12
Running water always purifies itself within a few miles.	43	22.5	135	296	45.60
All diseases require drugs (medicine) for their cure.	44	2	128	293	43.68
Unpleasant breath can be cured by using certain mouth washes.	45	56	125	296	42.22
Oculist is just another name for optometrist.	46	40	111	271	40.95
Drinking whiskey will delay freezing.	47	93.5	114	280	40.71
Scarlet fever is usually spread by the scales from the skin of the patient.	48	89	112	283	39.57
Tuberculosis can be inherited.	49	17.5	116	296	39.18
When a person is a licensed optometrist it means he is an eye specialist and is capable of treating any eye disease.	50	12.5	111	295	37.62
The scientific soundness of the chiropractor's claims can not be questioned.	51	71	81	218	37.15
The value of vaccination has been greatly exaggerated by medical men.	52	10	107	290	36.89
A dog is never "mad" unless it foams at the mouth and rushes about in an excited manner.	53	46	106	292	36.30
Cancer is a contagious disease.	54	49	105	295	35.59
Skin eruptions can usually be cured if one eats yeast regularly.	55	84.5	98	282	34.75
Sending a child to bed is a good method of punishment.	56	100	98	284	34.50
If a person wishes to remain healthy it is necessary for him to take doses of medicine occasionally.	57	53	102	297	34.34

There are many effective remedies for cancer.	58	36.5	100	297	33.67
Marriages between persons of opposite characteristics and personalities are more liable to be successful.	59	91	96	290	33.10
Girls should avoid all exercises during menstruation.	60	40	96	297	32.32
Many advertised cures for deafness are effective.	61	63	87	292	29.79
If a woman who is to become a mother is frightened, her child when born will probably bear a birthmark with some resemblance to the cause of her fright.	62	77	87	293	29.69
Colds can be cured by the use of alkali drinks.	63	43	76	259	29.34
When a characteristic is hereditary it will show up in all the offspring in a family.	64	45	85	294	28.91
Eye exercises are effective for arresting or curing failing eyesight.	65	96.5	80	279	28.67
An all vegetable diet is the natural and best diet for all persons.	66	33	82	294	27.89
For well-developed teeth, proper cleaning is more important than diet.	67	29.5	82	296	27.70
To go on a diet always means to eat less.	68	77	81	296	27.36
The great discoveries of science are usually kept secret and sold to "patent medicine" manufacturers.	69	91	72	276	26.08
If the teeth are brushed every day they will not decay.	70	25.5	72	295	24.40
Only bad or unpleasant odors are dangerous.	71	59.5	69	292	23.63
A child begins the formation of health habits when he starts attending school.	72	36.5	69	293	23.54
If a scientist believes something is true, then it is no doubt true.	73	53	69	295	23.38
The use of certain toothpastes will cure pyorrhea.	74	29.5	65	299	21.73
The use of certain toothpastes will prevent tooth decay.	75	22.5	62	299	20.73
Venereal diseases are seldom contracted by members of well-to-do privileged classes.	76	49	57	290	19.65
A mild case of scarlet fever can transmit only a mild case to another person.	77	20.5	58	296	19.59
Yeast is the only source of certain vitamins.	78	87	54	289	18.68
In order to transmit any disease a person must be actually suffering from the disease.	79	7.5	52	298	17.78
All cancers are incurable.	80	29.5	53	303	17.49
All men are born with equal physical and mental capacities.	81	20.5	50	298	16.77
Since a child will lose his first set of teeth, it is not necessary to begin dental care until the second set appears.	82	6	50	302	16.55
Persons must eat highly advertised foods in order to obtain a sufficient supply of vitamins.	83	63	49	300	16.33
All mental diseases are incurable.	84	25.5	48	295	16.27
Children should be exposed to childhood diseases.	85	7.5	49	309	15.85
A good remedy for snake bite is strong alcoholic drink.	86	67.5	47	299	15.71
Nasal sprays and eye drops can effectively cure hay fever.	87	67.5	45	298	15.10
Intelligent persons are usually weak physically.	88	91	36	289	12.45
Gonorrhea is no more serious than a bad cold.	89	12.5	35	297	11.78
If a person has enough faith that he will be cured, no other treatment is necessary for any disease.	90	36.5	34	293	11.60
Smallpox vaccination is often more serious than the disease.	91	33	33	303	10.89
Cancer can be properly treated by taking patent medicines.	92	10	13	200	6.50
If a person has the title "doctor" it signifies that he has had the same amount of training and education as any other doctor.	93	40	19	296	6.41
A cold bath every morning will prevent all illness.	94	96.5	18	285	6.31
If drinking water is clear, cold, and excellent in taste, it is always safe for drinking.	95	5	18	300	6.00
An effective relief for fatigue is cigarette smoking.	96	43	17	297	5.72
Venereal diseases can be successfully treated at home with "drug store remedies."	97	1	15	302	4.96
Cigarette smoking is good treatment for nervousness.	98	59.5	11	300	3.66
In the United States all persons have equal opportunities.	99	59.5	10	288	3.47
Syphilis will cure itself if permitted to run its course.	100	3.5	7	301	2.32

The findings of Table I are given below:

1. Only one misconception was responded to by all 318 of the teachers; however, each was responded to by a majority of them; 100 by 189 or more, 97 by 200 or more, 91 by 270 or more, 88 by 278 or more, 77 by 286 or more, 51 by 294 or more, and 8 by 302 or more of the in-service teachers.
2. No misconception was indicated as being false by all of the in-service teachers included in this study; 100 were believed to be true by 2.32 percent or more of the groups that responded to the misconceptions, 91 by 10 percent or more, 75 by 20 percent or more, 60 by 30 percent or more, 47 by 40 percent or more, 39 by 50 percent or more, 24 by 60 percent or more, 15 by 70 percent or more, and 6 by from 80 to 88.65 percent of the goup.

Additional findings of Table I may be summarized in Table IA:

TABLE IA

RANKS IN IMPORTANCE OF THE SCIENCE MISCONCEPTIONS ACCORDING TO THE PERCENTS OF RESPONSES OF TRUE FOR THESE MISCONCEPTIONS

*Percents	Ranks in Importance of the Misconceptions in Hancock's Study										
	1–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–100	Total
80–88.65			1		1		1	2	1		6
70–79	1	2			1		1		1	3	9
60–69		2	1		1		1	1	2	1	9
50–59		2	1	2	1	3		2	4		15
40–49	1	1			1	2	1	1		1	8
30–39		3		1	3	1		1	2	2	13
20–29			4	2	2	2	1	2		2	15
10–19	3	1	4	2	1		3		1	1	16
2.32–9	3	1			2	2				1	9

* Table 1A is read thus: Of the 6 misconceptions that were indicated as being true by 80–88.65 percent of the in-service teachers, one ranked (Hancock's study) respectively in each of the intervals 20–29, 40–49, 60–69, 80–89, and 2 in the interval 70–79, etc.

3. Of the 51 misconceptions that had ranks of 1–49, approximately one third of them were indicated as true by 50 percent or more of the group, while approximately two thirds were indicated as true by less than 50 percent of the group.
4. Of the 49 misconceptions that had ranks of 50–100, they were almost equally divided as to the number that were indicated as true by less than 50 percent and by 50 percent or more of the group.
5. Of the 24 misconceptions that were indicated by 60 percent or more of the group of teachers as being true, 7 had ranks within the upper 30, and 17 in the lower 70.
6. Of the 36 misconceptions that were indicated by from 30 to 59 percent of the in-service teachers as true, 8 had ranks within the upper 30 and 28 within the lower 70.
7. Of the misconceptions that were indicated by from 2.32 to 29 percent of the group of teachers, 16 had ranks within the upper 30 and 24 within the lower 70.

One part of the directions for the test stated, "If you cannot place a (T) or an (F) after a statement because you do not understand a word or an expression in that statement, kindly underscore the word or expression." Of the 318 in-service teachers, 111 followed that part of the directions. Some of the others, although they did not respond to a statement, did not follow those directions by underscoring a word or an expression in it. What the reasons were for not responding to a statement and not underscoring a word or an expression in it, the techniques used in this study did not reveal. Thus, each statement did not have 318 responses. However, there was a range of responses from a total of 189 for the statement, "An osteopath is a medical doctor (M. D.) who has specialized in the treatment of bone ailments," to a total of 318 for the statement, "Freezing kills bacteria."

A list was made of the words and expressions that were underscored by the in-service teachers and the frequency with which each word or expression was underscored was tabulated.

Table II shows the 14 words that were

most frequently underscored by a group of 111 in-service teachers.

TABLE II

THE FOURTEEN WORDS MOST FREQUENTLY UNDERSCORED

Words	Frequency
Osteopath	71
Chiropractor	48
Masturbation	34
Oculist	14
Optometrist	11
Alkali	10
Ovaltine	8
Malnourished	7
Gonorrhea	6
Feeblemindedness	6
Ailments	5
Hydrogen Peroxide	4
Colorblindness	4
Venereal	4

Table II is read thus: Of 111 in-service teachers, 71 did not know the meaning of osteopath, 48 chiropractor, 34 masturbation, etc.

In addition to the words that are listed in Table II, the following words or expressions with their frequencies were also underscored: Inoculation 3, exaggerated 3, theory 2, syphilis 2, yeast 2, nasal sprays 2, effective 2, bad blood 2, characteristics 2, cancer 2, and each of the following a frequency of 1: heredity, sore in the mouth, roughage, advertised, overstudy, transmit, venom, disinfect, vitamins, scarlet fever, patent medicine, and arresting.

CONCLUSIONS

In so far as the results of this investigation may be valid, the following conclusions seem justified:

1. The large number of misconceptions that were indicated as being true by a relatively high percentage of the in-service teachers is evidence that belief in the 100 popular science misconceptions compiled by Hancock is widespread among the in-service teachers in the common schools for Negroes in Georgia who were included in this study (Findings 1 and 2 of Table I).
2. If Hancock's conclusion be valid that the 100 misconceptions that were used in this study are the most important ones, of a list of 292 misconceptions, in terms of their potentialities for affecting the behavior of persons subservient to them, then the high percentage of in-service teachers who indicate thât the misconceptions are true is evidence that the behavior of these teachers may be influenced by these misconceptions. However, if it is assumed that the effect of a misconception of relatively high rank (1–49 in Hancock's study) on the behavior of one who is subservient to it is more marked than of one of relatively low rank (50–100 in Hancock's study), then the effect on the behavior of these teachers may be somewhat lessened by the slight indication that the misconceptions of relatively low rank are believed to be true by a larger percentage of the group than are those of relatively high rank (Findings 3–7, Table IA).
3. A total of 111 in-service teachers who did not respond to some of the statements because they did not understand words or expressions in them is evidence that among, at least, a third of the in-service teachers there is a lack of understanding of some of the words that occur in everyday experience. Moreover, some of the teachers who did not respond to all of the statements, although they gave no indication of the reasons for their not doing so, may not have responded because they, too, did not understand some of the words or expressions in them.

RECOMMENDATIONS

1. If the results of this investigation be defensible that there is widespread belief in the science misconceptions that were included in this study among the in-service teachers who attend summer school at The Fort Valley State College, then it is recommended that that institution include in its teacher training curriculums materials that are specifically designed to relieve in-service teachers of belief in these misconceptions. In its program of general education in all teacher training curriculums, The Fort Valley State College includes two general education science courses, one in the biological sciences and one in the physical sciences. Because of the nature of the content material implied in the science misconceptions that were used, that general education science course that includes experiences in the biological sciences would seem to be the place in which emphasis could be given to such material. However, if the College offered a course in health education that was common to all teacher

education programs, then such a course would be the logical place where emphasis could be given to these misconceptions because the majority of them may be considered to be directly related to health.

2. Additional studies of the kind that has been reported here should be made of other lists of science misconceptions for whatever contributions they may make toward developing course content for general education science courses.

3. In as much as all of the institutions for the higher education of Negroes in Georgia conduct summer schools in which practically the whole student enrollment consists of in-service teachers in the common schools of the state, it is, therefore, recommended that these institutions make studies similar to the one that has been described and that the results be used as one basis for developing content for their teacher education programs.

A SYLLABUS IN BIOLOGY FOR GENERAL EDUCATION II

The Preparation of a Syllabus Based Upon a Determination of the Relative Importance of the Biological Principles Judged in Terms of Criteria of General Education *

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In a previous issue † Part I stated the nature of the project, definitions and delimitations, the need and educational significance of the project, basic assumptions, and the procedures pertaining to the determination of the criteria of general education. In continuing with the procedures, the next phase dealt with the selection of the principles of biology.

SELECTING THE PRINCIPLES OF BIOLOGY

The selection of the principles of biology to be used in this project was undertaken in order to determine what principles of biology have important applications to the criteria (objectives) of general education. In selecting the principles of biology, the investigator analyzed four studies that listed many principles of biology. As a result of integrating and synthesizing the principles of biology from these studies, forty-two principles of biology were obtained. Several teachers of college biology assisted the investigator in selecting the principles of biology.

Students learn principles more efficiently than a vast array of isolated facts. This was one of the assumptions made in the previous paper. Facts become more significant when they are employed in the processes of deductive and inductive reasoning to enable individuals to understand principles and generalizations. It is also important to understand the social implications and applications of these principles.

Downing [1] states

> There are many problematic situations involving biology that arise in the life of the average person. Some of these are problems concerning which he must do something, as: What foods shall I eat? How can I most effectively avoid disease? What type of individual shall I marry? . . . Theoretically one might list all such questions that arise in a given community and teach the answers to every pupil in the biology work of the schools in that particular place, but that seems an impossible task, for the specific questions are so multitudinous. But the

* Paper presented at The National Association for Research in Science Teaching meeting, Atlantic City, New Jersey, February 18, 1951. Based on a document submitted in partial fulfillment of the requirements of the degree of Doctor of Education in the School of Education of New York University.

† Nathan S. Washton, Syllabus in Biology for General Education, Science Education, 35: 84–92, March, 1951.

principles of biology involved in them are relatively few. It is wiser, therefore, to give the pupils an understanding of the more important principles—important because they do help in solving these oft-recurring questions—and enough drill in applying them to typical life problems to insure skill in their use when the need may arise in their lives.

Four studies pertaining to the principles of biology were analyzed. The principles of biology listed by Martin were compared with the principles stated by other investigators. Forty-five principles of biology were listed [2] by Bergman in 1946 as a result of synthesizing previous investigations. Each principle was checked against those similar statements that appeared in four high school and four college biology texts; the selection of the eight texts was made in accordance with the judgments of twelve chairmen of high school departments of biology.

In 1932, Downing pooled the results of four separate studies conducted at the University of Chicago. He formulated a list of 28 principles of biology that are important for solving problems of everyday life. These principles originally appeared in weekly magazine articles, government publications, and popular science books. Of the 28 principles of biology, the compilation included 19 subordinate and 9 major principles: the major principles are listed in descending order of importance as follows:

I. Energy cannot be created or destroyed, but merely transformed from one form to another.
II. The ultimate source of the energy of all living things is sunlight.
III. Micro-organisms are the immediate cause of some diseases.
IV. All organisms must be adjusted to the environmental factors in order to survive the struggle for existence.
V. All life comes from previously existing life and reproduces its own kind.
VI. Animals and plants are not distributed uniformly or at random over the surface of the earth, but are found in definite zones and in local societies.
VII. Food, oxygen, certain optimal conditions of temperature, moisture, and light are essential to the life of most living things.
VIII. The cell is the structural and physiological unit in all organisms.
IX. The more complex organisms have been derived by natural processes from simpler ones, these in turn from still simpler, and so on back to the first living forms.

Winokur [3], in 1941, prepared an outline for an orientation unit in biological science and listed principles and generalized facts. He obtained the principles and generalizations by analyzing four college textbooks of biology, two textbooks of science orientation courses, and two biology books for the layman.

A more recent study was made by Martin [4] in 1944. One hundred principles of biology of importance for general education were listed in descending order of importance. The generalizations were obtained from an analysis of ten selected textbooks and reports of research studies pertaining to principles of science. A committee of nine experienced teachers and subject matter specialists in biology evaluated the generalizations in terms of criteria of a principle. An analysis was also made of four selected magazines and three newspapers to determine which principles of biology are essential for an intelligent understanding of these reading materials. The principles were evaluated by three experienced teachers and two selected laymen who determined whether these principles are suitable as objectives of instruction in general education. Martin writes:

The principles were then ranked on the basis of the ranks which each had received in the following three evaluations:

1. Total frequency of appearance of each in the textbooks and lists of research studies.
2. Total frequency of assignment of statements from magazine and newspaper articles to each, and
3. Total of the values assigned to each as an objective of instruction in general education.[5]

Utilizing the principles of biology that were formulated by others (Bergman, Downing, Winokur and Martin), the investigator compiled forty-two principles of biology. Martin's one hundred principles of biology were submitted to four specialists in college biology who recommended deletion of some of the principles to avoid duplication. Several of these principles were integrated into one inclusive prin-

ciple. The investigator obtained forty-two principles of biology with the aid of the four specialists.

In order to determine whether these forty-two principles of biology were satisfactory for the teaching of college biology, the investigator analyzed each of the biological principles that were stated in the studies by Bergman, Downing, and Winokur. These biological principles were compared with the forty-two principles that appear in this paper. In making this comparison, no additional principles were needed as the forty-two principles of biology in this paper include the principles of biology that were given by the other investigators (Bergman, Downing, and Winokur). The technique employed in comparing the biological principles was to examine one of the principles of biology listed by Bergman. The investigator examined each of the forty-two principles of biology in order to find the equivaelnt or corresponding principle of biology. This process was repeated for all of the biological principles and for all of the studies referred to above. In this way, a check was made to prevent an omission of an important biological principle that appeared in earlier studies.

Eight teachers of college biology examined the forty-two principles of biology and found them to be accurately stated. The forty-two principles of biology used in this syllabus are as follows:

1. A definite bodily disorder will occur when an endocrine gland ceases to function normally.
2. The cell is the structural and functional unit in most organisms.
3. The processes of a living body occur in the protoplasm; the sum of all of these chemical and physical processes is metabolism.
4. Life is perpetuated through the biological process of reproduction which provides new individuals.
5. Living organisms perform common life processes; reproduction, nutrition, growth, irritability, locomotion or movements of orientation and mutability.
6. Practically all the food in the world in addition to other substances are produced directly or indirectly through the process of photosynthesis where carbon dioxide and water, in the presence of sunlight and chlorophyl-bearing plants are converted into intermediate substances that ultimately form starch and liberate oxygen.
7. Different kinds of plants and animals form communities based on their interrelations with one another and with their physical environment.
8. Fermentation and putrefaction are usually caused by living micro-organisms.
9. Food, oxygen, certain optimal conditions of temperature, light, and moisture are required for the life of most living organisms.
10. The higher forms of terrestrial life are dependent either directly or indirectly on the soil bacteria for their nitrogen supply.
11. Some micro-organisms cause disease when they enter the host through an appropriate avenue in sufficient numbers, are virulent, and the host is receptive to the specific disease.
12. All living things receive and respond to stimuli and attempt to adjust themselves in their environment.
13. Living things alter their types; species that exist today have originated by descent from earlier ones which were derived from still earlier ones, down to the first living forms.
14. A parasitic organism harms its host by injuring the tissues, by liberating poisons (toxins) within the body of the host for food, or by preventing reproduction of the host.
15. All living organisms are gradually changing, in structure and function, in response to changes in their physical environment.
16. Digestion in plants and animals occurs through the action of enzymes which are manufactured by the organisms.
17. Enzymes, vitamins, and hormones are chemical substances that govern the reactions that occur in living things.
18. The ultimate source of the energy of all living things is sunlight and is obtained by organisms through the oxidation of food.
19. Regeneration is a common occurrence among living things and takes place less frequently in organisms as their bodies become more specialized.
20. Saprophytes cause decay by which process necessary raw materials are produced from dead matter for the growth of new organisms.
21. Although living things are not distributed uniformly or at random over the surface of the earth, they are found in definite zones and in local societies where conditions usually are favorable to their survival.
22. The antitoxins produced by the body of an organism are specific and tend to build up in the individual an immunity to disease.
23. The earth's surface and its surrounding atmosphere are changing constantly and demand that organisms migrate, hibernate, aestivate, build artificial shelters or otherwise become adapted to these changes.
24. The higher forms of life are more complex in structure and are accompanied by an increase in division of labor.
25. Osmosis, the diffusion of molecules of water

through a semi-permeable membrane from the region of higher concentration to a region of lower concentration, with a stoppage of the flow of molecules of the solute, is a basic process in plant and animal physiology.

26. Living things are more likely to survive and reproduce when they are structurally and physiologically best fitted to their environments.
27. Each organism is composed of specific hereditary characters which are transmitted from one generation to the next through given hereditary factors.
28. All living things require proteins for cell growth and maintenance. Animals procure them in their diets; plants can synthesize proteins from carbohydrates and nitrates.
29. New types of living organisms may arise through mutation.
30. All gradations of association occur in intimate associations between organisms, from those which are mutually beneficial to the individuals concerned (symbiosis) to those which are parasites.
31. Digestion accomplishes two things; it makes insoluble and indiffusible foods soluble and diffusible; it breaks down complex nutrients to simpler substances that are synthesized into living and other materials that are needed by an organism.
32. Since hereditary factors (genes) of two parents combine at random during fertilization, the individuals of the following generation occur in certain predictable ratios.
33. With few exceptions, the range of temperature for life activities is from many degrees below 0°C. to nearly the boiling point of water.
34. Cell division is a fundamental process of reproduction in organisms whose cells possess nuclei which results in a precise distribution of the chromatin of the nucleus.
35. Hereditary traits in most organisms are determined by the genes which are carried in the chromosomes.
36. The carbon cyle occurs in nature as a result of the decomposition of carbon compounds of organisms which replenishes the carbon supply in the atmosphere in the form of carbon dioxides.
37. All living things with the exception of several anaerobic and autotrophic bacteria, obtain their energy through the oxidation of food.
38. Living things produce a multitude of individuals, many more than can survive, varying more or less among themselves, and all competing against each other for the available food and energy.
39. Living things require food and other substances; fuels to supply energy, materials for growth and replacement, minerals and water for cell structures and cell products.
40. A single fertilized egg cell develops into an embryo and grows through a series of divisions into the form of the organism.
41. The modes of reproduction of living things fall into two general categories: asexual and sexual reproduction. Sexual reproduction is the almost universal method and occurs in species of every phylum of plants and animals.
42. Heredity provides an organism with its native capacities whereas environment determines to a large extent how fully these potentialities will be developed.

To arrive at the basic principles for this project, the investigator started with the one hundred principles of biology of importance for general education that were listed by Martin. Four professors of biology were consulted in determining which principles of the one hundred listed by Martin should be utilized in teaching a college course of biology. Each of the four specialists were given copies of Martin's one hundred principles of biology of importance for general education. They were asked to analyze these principles and to comment as to which of these principles should be taught in a college biology course for general education. Each professor of biology discussed the limitations and exceptions noted for each principle with the investigator. The specialists indicated that several principles stated by Martin could be integrated into one all inclusive principle in order to avoid duplication. Forty-two principles of biology were obtained as a result of consolidating "sub-principles." These forty-two principles were compared with those listed by Bergman, Downing and Winokur to determine if these principles were comprehensive and accurately stated. It was found that the list of forty-two principles of biology contained all of the principles and were in accord with the principles reported by Bergman, Downing and Winokur. The investigator consulted eight teachers of college biology who examined these forty-two principles and found them to be accurately stated.

The principles are not necessarily listed in their order of importance. They do not indicate the order in which they would be taught in the course. Although the investigator obtained forty-two principles, it is likely that others may reduce this number by consolidating and integrating several principles.

APPLYING BIOLOGICAL PRINCIPLES TO CRITERIA OF GENERAL EDUCATION

Since the criteria of general education and the principles of biology were determined, it was feasible to apply the principles of biology to the criteria of general education. The investigator sought the judgments from thirty experienced teachers of college biology as to which principles of biology are MOST IMPORTANT, IMPORTANT, or UNIMPORTANT in applying them to the criteria of general education. These judgments were used as the basis for constructing the syllabus.

A questionnaire which lists the criteria of general education (stated as objectives) and the principles of biology was prepared. Thirty experienced teachers of biology for general education in colleges were asked to respond to the questionnaire. They were requested to evaluate the relative importance of the principles of biology in terms of their application to the objectives of general education. Twenty-five teachers replied. The judgments of the teachers are indicated by the *objectives of general education* that appear under each principle in the syllabus as follows: *Whenever an asterisk precedes an objective, it signifies that more than fifty per cent of the respondees believe that the principle of biology is MOST IMPORTANT for application to this objective.* The objectives or criteria that do not have asterisks are considered IMPORTANT. The criteria or objectives of general education that are considered UNIMPORTANT were omitted in this syllabus. The objectives of general education that appear under each principle in this syllabus are not listed in their order of importance.

All of the teachers indicated that the forty-two principles of biology were either MOST IMPORTANT or IMPORTANT in applying them to the objective that provides students with the necessary knowledge, skills, and attitudes in order that students may understand the world of nature, physical and biological, and be able to interpret natural phenomena, which appears first in the list of Criteria of General Education. More than fifty per cent of the teachers indicated that most of the forty-two principles of biology were either MOST IMPORTANT or IMPORTANT in applying them to the following three objectives of general education: (1) Gain a better understanding of the meaning and purpose of life and a truer sense of values; (2) Maintain and improve their health and share in the responsibility for protecting the health of the community; (3) Utilize a scientific approach in solving problems dealing with society and human welfare. Based upon the judgments of the twenty-five teachers of college biology, it appears that most of the forty-two principles of biology have applications to at least three of the objectives of general education which were stated above.

Other significant findings that indicate a relationship between principles of biology and objectives of general education were noted. More than fifty per cent of the teachers judged principles of biology that pertained to behavior (Principles 1 and 12), reproduction (Principles 40 and 41), heredity (Principles 27, 32, 35, 42), and evolution (Principles 26 and 38) as either MOST IMPORTANT or IMPORTANT in applying them to the following two objectives for general education: (1) Attain an emotionally stable personality and make a worthy social adjustment; (2) Be better fit for successful family and marital relationships. The principles of biology that deal with heredity and evolution were also judged to be either MOST IMPORTANT or IMPORTANT in applying these principles to the following three objectives: (1) Understand the social, economic and spiritual forces at work in society and develop a sense of social responsibility; (2) Participate more effectively in solving problems of contemporary society; (3) Recognize the interdependence of the different peoples of the world. These objectives were also rated most frequently

for principles of biology that pertain to ecology, plant-animal relationships (Principles 7, 9, 10, 21, 30).

The principles of biology pertaining to nutrition (Principles 6, 28, 39) were judged either as MOST IMPORTANT or IMPORTANT in applying them to the following objectives: (1) Participate more effectively in solving problems of contemporary society; (2) To understand the place of the consumer in society and to learn to become an intelligent consumer of goods, services and time. These findings were utilized in constructing a syllabus in biology for general education which is described below.

CONSTRUCTING THE SYLLABUS

In constructing the syllabus, the following pattern was employed. For each principle of biology are listed the objectives of general education. Whenever an asterisk precedes an objective, it signifies that more than fifty per cent of the teachers responding to the questionnaire believe that the principle of biology is MOST IMPORTANT for application to this objective. The objectives that do not have asterisks were considered IMPORTANT. In order to attain the objectives of general education for each principle of biology, a group of learning activities is suggested.

The learning activities under the principles of biology were chosen from textbooks and other publications in the biological sciences that are listed in the bibliography. The investigator carefully examined these books to determine where pertinent information is given that would enable the reader to obtain an understanding of each principle of biology in this document. As a result of reading these texts, the investigator formulated an outline of student-teacher discussions for each principle of biology. Specific references that were used in preparing the outline of student-teacher discussions appear in the syllabus, Chapter IV, for each principle of biology.

The technique used by the investigator was to write one principle of biology followed by the MOST IMPORTANT and IMPORTANT objectives of general education. All of the textbooks listed in the bibliography were examined for pertinent information that would provide the reader with an understanding of the biological principle. These texts that treated the information pertaining to the principle of biology more adequately were listed as basic references. Optional references were listed for a more thorough understanding of the biological principle if the reader of the syllabus had additional time for further study. Thus, the outline of the student-teacher discussion was prepared from these readings for each principle of biology.

During the process of reading the various publications, the investigator was searching for suggested learning activities that would enable students to understand and apply the biological principle in relation to the objectives of general education. These activities were listed for each principle of biology. The activities include student participation in field trips, visits to museums, parks, and various agencies, student observation of motion picture films, projection of photographs, slides and illustrations, student experimentation at home and at school, the preparation of oral and written reports by students, and suggested readings. The investigator examined catalogs of equipment and of other audio-visual aids that may be obtained from various commercial sources and listed these aids to learning for each principle of biology.

The proposed learning activities for each principle of biology was discussed with eight teachers of college biology. At weekly conferences and at other frequent meetings during the academic year, the investigator stated the biological principles, the objectives of general education for each principle and the proposed learning activities. Comments and suggestions as to what other learning activities should be included in the syllabus were invited. A few minor changes were suggested and several addi-

tional audio-visual aids to learning principles of biology were proposed by the eight teachers. As a result of group and individual conferences with his colleagues, the investigator listed the learning activities for each principle of biology in relation to the objectives of general education.

To summarize, the selection of learning activities that appears in this syllabus under each principle of biology is determined by (1) an examination of textbooks, books, and journals that are listed in the bibliography, *Readings in the Biological Sciences;* (2) consulting eight specialists in the biological sciences who are teaching college biology; (3) the experience of the investigator who taught biology for general education for three years at Newark Junior College and for three years at the Newark Colleges of Arts and Science, Rutgers University.

In designing this syllabus, the forty-two principles of biology were listed as a result of the studies described in this paper. For each principle of biology, there appear several criteria for general education that are stated as objectives. Whenever an asterisk precedes an objective, it signifies that more than fifty per cent of the twenty-five teachers of college biology judged the principle of biology as MOST IMPORTANT in applying it to that objective. The absence of an asterisk before the objective indicates that more than fifty per cent of the twenty-five teachers of college biology judged the principles of biology as IMPORTANT in applying it to that objective.

A SAMPLE OF THE SYLLABUS

PRINCIPLE # 1

A DEFINITE BODILY DISORDER WILL OCCUR WHEN AN ENDOCRINE GLAND CEASES TO FUNCTION NORMALLY.

Objectives (General Education)

*1. Maintain and improve their health and share in the responsibility for protecting the health of the community.
*2. Be better fit for successful family and marital relationships.
*3. Attain an emotionally stable personality and make a worthy social adjustment.
4. Utilize a scientific approach in solving problems dealing with society and human welfare.
5. Understand the world of nature, physical and biological, and be able to interpret natural phenomena.

Learning Activities

I. Student-teacher discussion of:
  A. Diabetes (glycosuria)
    1. causes
      a. functional failure of cells in islands of Langerhans
      b. deficiency of insulin
    2. effects
      a. sugar in urine
      b. increase of sugar in blood
      c. glycogen in liver
      d. acidosis
  B. Hypothyroidism—(diminished secretion of thyroxin) effects
    1. simple goiter—(endemic goiter)—decrease of iodine content
      a. enlarged gland
      b. obesity and sluggishness
    2. cretinism—in children
      a. bloated face
      b. pot-bellied abdomen
      c. thick protruding tongue
      d. arrested mental development
    3. myxedema—in adults (atrophy of gland)
      a. swollen face and hands
      b. rough, waxy, dry skin
      c. falling hair
      d. decreasing metabolism
      e. defective memory
      f. twitchings and tremors
  C. Hyperthyroidism—(increased secretion of thyroxin) effects
    1. increasing metabolic rate
    2. increasing body temperature
    3. more rapid blood circulation
    4. irritable and more tense (nervous)
    5. protruding eyeballs
    6. overstimulation of heart muscles
    7. insomnia
  D. Hypoparathyroidism—(diminished secretion of parathyroid hormone) effects
    1. tetany—rigid muscles
    2. decrease of calcium in blood
    3. loss of hair, nails and teeth
  E. Hyperparathyroidism—(increased secretion of parathyroid hormone) effects
    1. increase of calcium in blood and urine
    2. muscular weakness
    3. pain in bones and muscles
  F. Emotional disturbances—(excessive secretion of adrenalin) effects
    1. increased blood flow to heart, body muscles and central nervous system
    2. formation of blood clots
    3. increases change of glycogen into glucose in liver
  G. Neurasthenia—(diminished secretion of adrenalin) effects
    1. premature fatigue

2. muscle and nerve weakness
3. irritable
4. increased blood pressure

H. Addison's disease—(pathologic condition in the cortex of adrenals) effects
1. brown pigmented skin
2. progressive anemia
3. severe prostration

I. Hypopituitarism—dwarf—(decreased secretion of hypophysis, anterior lobe) effects
1. short body, long extremities
2. obesity
3. smooth, dry skin
4. genital atrophy

J. Acromegaly—adults—(increased secretion of hypophysis, anterior lobe) effects
1. prominent lower jaw
2. enlargement of the bones of the hands, feet and face

K. Gigantism—formative years—(increased secretion of hypophysis, anterior lobe)

II. Visual Aids—Use of Opaque Projector
A. Photographs of Dwarfism and Gigantism on page 105, Strausbaugh and Weimer, *General Biology*
B. Photograph of effects of insulin on page 108, Strausbaugh and Weimer, *General Biology*

III. Student Activity
Some students may wish to obtain living tadpoles and thyroxin for an experiment to be done at home. The effects of thyroxin when added in small doses to a tank of tadpoles will produce interesting developmental changes. Daily observations should be made and accurate records should be kept. Compare these results with a tank of tadpoles to which no thyroxin was added.

IV. Demonstration
Procure the Frog Pituitary Set (includes one unit of frog pituitary suspension, one living female grassfrog, two living male grassfrogs and detailed instructions for producing laboratory-induced eggs) from the General Biological Supply House, Chicago, Illinois.

References *

Basic: (4) Beaver, pp. 747–752
(31) Jean et al., pp. 202–229
(64) Strausbaugh and Weimer, pp. 101–110
(73) Young et al., pp. 171–179

Optional: (3) Baitsell, pp. 103–117
(22) Guyer, pp. 285–297
(29) Hoskins (entire book)
(45) Millard and King, pp 356–362
(68) Voronoff, (entire book)
(38) MacDougall and Hegner, pp. 618–627

Questions

1. How are hormones employed by medical practitioners to cure and prevent certain ailments in individuals?
2. How does a knowledge of endocrine glands affect fitness for successful family and marital relationships?
3. To what extent do endocrine glands and their secretions influence the personality of an individual? What can we do about it?
4. How do the hormones of the pituitary gland affect the hormones of other endocrine glands?

* The number in parenthesis preceding the author's name under references for each Principle refers to the corresponding reference listed in the Bibliography, 1. READINGS IN THE BIOLOGICAL SCIENCES.

PRINCIPLE # 7

DIFFERENT KINDS OF PLANTS AND ANIMALS FORM COMMUNITIES BASED ON THEIR INTERRELATIONS WITH ONE ANOTHER AND WITH THEIR PHYSICAL ENVIRONMENT.

Objectives (General Education)

*1. Understand the world of nature, physical and biological, and be able to interpret natural phenomena.
*2. Gain a better understanding of the meaning and purpose of life and a truer sense of values.
*3. Utilize a scientific approach in solving problems dealing with society and human welfare.
4. Understand the social, economic and spiritual forces at work in society and develop a sense of social responsibility.
5. Recognize the interdependence of the different peoples of the world.
6. Participate more effectively in solving problems of contemporary society.
7. Have some appreciation of the background of the civilization which is our heritage.
8. Maintain and improve their health and share in the responsibility for protecting the health of the community.

Learning Activities

I. Student-teacher discussion of:
A. Plant and animal interrelations
1. vegetation and distribution of animals
a. blanketing effect of plants
(1) rain
(2) light
(3) heat
(4) evaporation from soil surface
b. competition between plant communities
c. life zones
(1) vegetarian birds in plant communities
(2) common grass-mouse (Microtus agrestis)
(a) habitat underground in grassland
(b) food roots of grass
(3) oaks (Quercus robur) supporting hundreds of insects
(4) sea and fresh water lakes
(a) penetration of sunlight at different depths
(b) different food habits of sea life

B. Ecological succession
1. slow movement of plant associations
a. erosion
b. deposition
c. disasters (fires, floods, droughts, avalanches)
2. development of plant communities (e.g., beech and maple forest)
a. bare rock
b. crustose lichen
c. lichen-moss community
d. herbaceous plant community
e. shrub community
f. xeric tree community (oaks and hickories)
g. mesic tree community (beech and maple)
3. development of animal communities
a. food-chains and the food cycle
b. size of food
c. status and function of animals in the biotic environment (niche)
d. usually larger animals eating smaller animals
e. small animals reproducing faster than large ones and supporting the larger animals

II. Visual Aides
A. Opaque Projector—diagrams showing food-cycle among animals and general food relations on page 58, Elton's *Animal Ecology.*
B. Blackboard diagram: conception of a community, page 308, Fitzpatrick, *The Control of Organisms.*
C. Movie film (silent, 16mm), "The Forests." Can be rented from American Nature Association, 121–16th Street, N.W., Washington, D. C. (Other films pertaining to plant and animal interrelationships may be rented from the American Museum of Natural History, Central Park West and 79th Street, New York City.)

III. Individual Student Activities
Make an ecological study of a given locality near your home. It may be in the woods, in the park or in or near a lake. Confine the study to an area of less than one acre. Identify and list a few different species of plants and animals. Observe the food habits and food relations of these organisms in their habitat. It may be necessary to turn over rocks, decaying logs and branches of trees in order to uncover various living plants and animals. Prepare a written report based upon a series of observations and indicate the interrelations of plants and animals with one another and with their physical environment.

References

Basic: (31) Jean et al., pp. 322–380
(18) Fitzpatrick, pp. 275–318
(38) MacDougall and Hegner, pp. 48–61
(64) Strausbaugh and Weimer, pp. 457–479
Optional: (41) McDougall, pp. 214–227: 249-265
(15) Elton, pp. 18–32: 50–70
(56) Shelford, V. E. (entire book)

Questions

1. Do competition and cooperation occur between living plants and animals? How does the physical environment affect the competition for food among living organisms?
2. Discuss how some birds and other animals control the damage done by insect pests, weeds, and rodents.
3. How do interrelations of plants and animals affect the economic, social, and health needs of man?
4. How do plants and animals influence the interdependence of the different peoples of the worlds?

PRINCIPLE # 12

LIVING THINGS RECEIVE AND RESPOND TO STIMULI AND ATTEMPT TO ADJUST THEMSELVES TO THEIR ENVIRONMENT.

Objectives (General Education)

*1. Understand the world of nature, physical and biological, and be able to interpret natural phenomena.
2. Gain a better understanding of the meaning and purpose of life and a truer sense of values.
3. Attain an emotionally stable personality and make a worthy social adjustment.
4. Utilize a scientific approach in solving problems dealing with society and human welfare.
5. Maintain and improve their health and share in the responsibility for protecting the health of the community.
6. Participate more effectively in solving problems of contemporary society.
7. Be better fit for successful family and marital relationships.

Learning Activities

I. Student-teacher discussion of:
A. Stimuli
1. thermal
2. mechanical (contact, pressure, sound)
3. chemical
4. electrical
5. photic
B. Plants and their adjustments
1. tropisms
a. chemotropism—response to chemicals
b. chromotropism—response to color
c. electrotropism—response to electric current
d. geotropism—response to gravity
e. heliotropism—response to sun
f. hydrotropism—response to water
g. phototropism—response to light
h. thermotropism—response to heat
i. thigmotropism — response to contact (touch)

2. other movements by plants
   a. nasties
   b. autonomic
   c. paratonic
   d. circumnutation
   e. turgor
   f. photeolic

C. Animals and their adjustments
1. nervous system in lower animals
   a. hydra (nerve net)
   b. verticella (myonemas)
   c. earthworm
2. nervous system in the human
   a. central nervous system
      (1) spinal cord
      (2) brain
         (a) cerebrum
         (b) cerebellum
         (c) medulla oblongata
   b. autonomic nervous system
   c. reflex arc
   d. microscopic anatomy and functions
      (1) neuron (nerve cell)
         (a) dendrite
         (b) cell body
         (c) axon
         (d) synapse
      (2) kinds of neurons
         (a) sensory (afferent)
         (b) connector (intermediate)
         (c) motor (efferent)
      (3) central nervous tissues
         (a) myelinated—white matter regions
         (b) non-myelinated — gray matter regions
      (1) ganglia
      (2) parasympathetic division
         (a) cranial
         (b) sacral
      (3) sympathetic division
   e. gross anatomy and functions
      (1) receptors
         (a) eye
            i. cornea
            ii. scleroid layer
            iii. choroid
            iv. iris
            v. retina
         (b) ear
            i. outer ear
            ii. middle ear (Eustachian tube, hammer, anvil, stirrup)
            iii. inner ear
            iv. organs of equilibrium
         (c) organs of taste and smell
            i. taste buds
            ii. fundamental tastes
               sweet
               salt
               bitter
               sour
         (d) somasthetic receptors
            i. touch
            ii. pressure
            iii. pain
            iv. temperature
      (2) conductors
      (3) effectors
         (a) muscles
            i. skeletal
            ii. smooth
            iii. cardiac
         (b) glands
            (endocrine glands and behavior refer to principle No. 1)

II. Visual Aids
   A. 16mm sound films (from Knowledge Builders, McCrory Studios, 130 West 46 Street, New York City).
      1. "How the ear functions"
      2. "How the eye functions"
   B. Charts and models of:
      1. eye
      2. ear
      3. nervous system

III. Individual Student Activity
   A. Dissection of
      1. brain of sheep (observe anatomy and physiology)
      2. nervous system of earthworm (observe anatomy and physiology)
   B. Prepare a report on the observation of a plant or animal in terms of its behavior. Discuss the stimuli and the response made by the living organism.

IV. Demonstrations
   A. Micro-projector showing the "avoiding reaction" in living paramecium—with a needle, shred about ½ sq. in. of lens paper on a slide. These shreds should resemble minute hair-like fibres which will serve to block the pathways of living paremecia. Add one or two drops from the paramecium culture. Carefully place the cover slip on the droplets. Observe the "avoiding reaction" in paramecium.
   B. Contraction of an excised gastrocnemius muscle from the hind leg of a frog. By means of a kymograph, a graphic record may be obtained when the freshly excised muscle, treated with Ringer's solution, is stimulated by electrical shocks.
   (Materials needed for this demonstration are: Frog, dissection set and pan, frog board and clips, kymograph and paper, paste, muscle lever, thread, muscle clamp, ring stand, right angle clamp, inductorium, batteries, wires, key (switch), electrodes, Ringer's solution, medicine droppers.)

References

Basic: (3) Baitsell, pp. 179–182: 214–278
(31) Jean et al., pp. 167–230
(38) MacDougall and Hegner, pp. 596–642
(64) Strausbaugh and Weiner, pp. 150–190
(73) Young et al., pp. 411–619
Optional: (22) Guyer, pp. 313–367
(40) Mavor, pp. 618–658

Questions

1. What is the relationship between one's personality and the ability to adjust oneself to different stimuli?
2. How to plants, lower animals, and man differ in their abilities to adjust themselves to a changing environment?
3. How can good mental health be maintained and improved in the home and in the community? What responsibilities should citizens assume for those who suffer from poor mental health?

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TEACHING BIOLOGY FOR GENERAL EDUCATION *

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How can we teach biology for general education? Many teachers believe that the emphasis of biological data or knowledge, per se, without relationship to other areas of knowledge and living is adequate for the development of a general education program. Perhaps there are a few teachers who believe that biological knowledge should be diluted in order to develop the aims of a general education. Both of these extreme points of view have serious limitations. In one of the recent studies,[1] the writer determined the criteria of general education, the principles of biology for general education, and their applications to specific purposes of general education. A syllabus in biology for general education was prepared as a result of this study.

The approach to teaching biology for general education will vary in terms of emphasizing the "content" objectives, "attitudinal" objectives, or other kinds of objectives. It is not suggested that the following proposal be employed as the best means of teaching biology. There should be flexibility in content, materials and methods of teaching to meet the needs of individual students and communities. However, it is significant to note the response by twenty-five teachers of biology, most of whom are members of the National Association for Research in Science Teaching to a questionnaire. The majority of these teachers indicated the following:

1. Teach biological principles pertaining to behavior, reproduction, heredity, and evolution in order that students may be provided with the necessary knowledge, skills, and attitudes to (a) attain an emotionally stable personality and make a worthy social adjustment; (b) be better fit for successful family and marital relationships.

2. Teach the principles pertaining to heredity and evolution in order that students (a) understand the social, economic, and spiritual forces at work in society and develop a sense of social responsibility; (b) participate more effectively in solving problems of contemporary society; (c) recognize the interdependence of the different peoples of the world.

* Paper presented to the National Association for Research in Science Teaching, annual conference held in Atlantic City, New Jersey, February 1951 and to section Q, (Education) of the American Association for the Advancement of Science, December 28, 1951, held in Philadelphia, Pa.

[1] Washton, Nathan S., "A Syllabus in Biology for General Education." Science Education 35: 84–92 (March, 1951).

3. Teach the principles pertaining to nutrition in order that students (a) understand the place of the consumer in society and learn to become intelligent consumers of goods, services and time; (b) participate more effectively in solving problems of contemporary society.

4. All of the principles of biology should be emphasized to students in terms of the following objectives of general education: (1) gain a better understanding of the meaning and purpose of life and a truer sense of values; (2) maintain and improve their health and share in the responsibility for protecting the health of the community; (3) utilize a scientific approach in solving problems dealing with society and human welfare.

Each instructor may wish to organize the principles of biology in terms of the needs of a given geographical area or other criteria based upon psychological principles of learning. Some instructors may wish to consolidate or integrate several principles into another form of generalization. Other instructors may find it necessary to omit some biological principles due to lack of sufficient time. Based upon the writer's teaching experience, the following order in which the principles of biology may be taught may serve as a guide:

A. Protoplasm and the Cell
B. Energy and Life
C. Ecology, Plant-Animal Relationships
D. Nutrition
E. Behavior
F. Reproduction and Development
G. Heredity
H. Evolution
I. Applied Biology

It may be more desirable for an instructor to organize the course beginning with Applied Biology and ending with Protoplasm and the Cell. Each instructor can justify his organization of the course in terms of psychological principles of learning.

The psychological factor considered is that learning is economical when one proceeds from the simple to the complex, i.e., the principles dealing with protoplasm are simple when compared with the more complex principles of biology pertaining to heredity and evolution. However, it would still be psychologically sound if an instructor began teaching biology with those principles and materials that are *known* to students and gradually proceeded to the *unknown*, i.e., experiences dealing with applied biology (health, functions of the body); these experiences are known to students as compared with a knowledge pertaining to the structures and functions of a cell that are usually unknown to beginning students. Perhaps further experimentation in educational research is needed to answer the problem of what scientific basis, if any, should be employed, in organizing the order in which materials and principles should be taught in a course in biology.

The approach to teaching biology for general education is very significant. Martin writes, "All of the principles lend themselves to the understanding and use of the scientific approach if the teacher uses the problem approach and the inductive method for developing an understanding of the principles and the deductive method for applying the principle to everyday familiar happenings." [2] Some instructors may wish to restate the principles of biology as problems, employing the problem method of teaching. Bless [3] states: "It would be best and more in keeping with our problems of education if we omitted many topics concentrating our attention on the important ones and spent some time in showing the relation and application of these principles to our every day life and to the development of our ideas."

"Science is today on a plane of high significance and importance. It is no longer, if indeed it ever was, a mysterious and occult hocus pocus to be known only to a select few. It touches, influences, and molds the lives of every living thing. Science teachers have a great opportunity and responsibility to make a large contribution to the welfare

[2] Martin, W. Edgar, in a letter addressed to the writer dated January 17, 1949.

[3] Bless, Arthur A., "Aims of a College Course in Science." *Journal of Chemical Education*, 9 (May, 1932), p. 659.

and advancement of humanity. The intellectual aspects of this responsibility are at least coequal in importance with the material. Science is a great social force as well as a method of investigation. The understanding and acceptance of these facts and this point of view and their implementation in practice will, more than anything else make science teaching what it can and should be." [4]

It is suggested that the teacher not only teach principles of biology but also the objectives of general education. Questions should be encouraged from students that would stimulate their thinking along the implications and applications of biology to every day living. The art of asking questions and in formulating additional questions are functions of the teacher. The effectiveness with which the teacher employs suitable methods of teaching may determine the success of developing the objectives of general education. The following outline may serve as an illustration of how to teach one among several principles of biology that pertain to heredity.

HEREDITY PROVIDES AN ORGANISM WITH ITS NATIVE CAPACITIES WHEREAS ENVIRONMENT DETERMINES TO A LARGE EXTENT HOW FULLY THESE POTENTIALITIES WILL BE DEVELOPED.

Objectives—General Education

1. Understand the world of nature, physical and biological, and be able to interpret natural phenomena.
2. Participate more effectively in solving problems of contemporary society.
3. Gain a better understanding of the meaning and purpose of life and a truer sense of values.
4. Have some appreciation of the background of the civilization which is our heritage.
5. Understand the social, economic, and spiritual forces at work in society and develop a sense of social responsibility.
6. Maintain and improve their health and share in the responsibility for protecting the health of the community.
7. Attain an emotionally stable personality and make a worthy social adjustment.
8. Utilize a scientific approach in solving problems dealing with society and human welfare.
9. Be better fit for successful family and marital relationships.
10. Develop a code of behavior which is based on ethical principles consistent with democratic ideals.
11. Recognize the interdependence of the different peoples of the world.
12. Discover their own abilities, aptitudes, and interests and choose a vocation.

Learning Activities

I. Student-teacher discussion of:
  A. Heredity and environment
    1. environmental conditions affecting development and transforming adult features of an organism
      a. plant response to environmental changes
        (1) Chinese primula (temperature—color)
        (2) maize (sunlight—color)
      b. animal response to environmental changes
        (1) green parrots of South America (diet—plumage)
        (2) Axolott vs. Amblystoma (water—gills)
        (3) common sea minnow (Fundulus) (chemicals—number of eyes)
    2. mental differences in humans
      a. the effects of heredity, environment, and educational opportunity
      b. attitudes influenced by
        (1) religion
        (2) economic theories
        (3) race prejudice
      c. environmental effects
        (1) twins of unlike sex vs. identical and fraternal twins of same sex
        (2) twins reared in same home vs. twins reared in different homes
        (3) normal child vs. imbecile (effects of iodine and thyroid gland)
  B. Eugenics
    1. marriage
    2. segregation and sterilization
    3. education
    4. immigration
    5. dangers and difficulties
      a. inbreeding
      b. war
  C. Euthenics
    1. sociological factors
    2. economic factors
    3. political factors

II. Visual Aids—opaque projection of:
  A. Three photographs of the same child suffering from thyroid deficiency, on page 114, Holmes' *Human Genetics and Its Social Import*. New York: McGraw-Hill Book Company, 1936.
  B. Photograph of Japanese twins (identical) but unequal development, on page 122, Holmes' *Human Genetics and Its Social Import*. New York: McGraw-Hill Book Company, 1936.

[4] National Society for the Study of Education. *Forty-Sixth Yearbook*, Part I. Science Education in the American Schools. Chicago: University of Chicago Press. 1947, p. 39.

III. Individual Student Activity
Determine the noticeable differences and similarities in several traits such as stature, color of eyes, hair, intelligence, character and temperament among the members of your family. How can you account for these differences and similarities as a result of heredity and environment?

Questions

1. How do heredity and environment influence the personality of an individual? What is the relationship of one's personality to social adjustment?
2. How can scientific thinking be applied to minimize or eliminate prejudice pertaining to heredity and environment? To what extent do economic theories, religion and race prejudice influence these attitudes?
3. What knowledge is available from the study of heredity and environment that may be applied to successful family and marital adjustments?
4. What are the advantages, disadvantages, and limitations of a eugenics program in America? Of a euthenics program?

The above outline suggests that biology may be taught in relationship to sociology, psychology, anthropology, and economics. Other illustrations are found in the paper which precedes this paper. The process of living is not confined to a given academic subject. In living, students have many problems to solve. How can the teaching of biology help the student solve some of his problems or at least make a contribution to solve real problems?

The teaching of biological principles could be adapted to solving problems of living. Problems of living are common to all mankind, regardless of acquired interests, aptitudes, or vocational choice. All people have social, personal, family, and vocational problems. Every individual is concerned with such problems as: How can I get along with my friends and neighbors? How shall I select my mate? What job or profession shall I prepare for? How can I use my income for better security and live an enriched life? How can I maintain and improve good health? What attitudes, interests, and skills can I develop that would produce a better life? What problems shall I consider in marriage and in rearing a family? No one course or subject will give the answers to all of these problems. Good instruction that emphasizes relationships or implications and applications from biology, sociology, economics, psychology, and other areas should make possible a good program of instruction for general education. The techniques for integrating instruction will vary among teachers as well as schools. It is suggested that problem solving and other methods of integrating instruction be employed in order to fulfill the aims of a general education. It should be the function of general education to help students solve their problems, and advance the welfare of the individual and the public. With this goal in view, teachers of biology can make a worthwhile contribution.

STUDIES IN MENTAL RIGIDITY AND THE SCIENTIFIC METHOD *

I. Rigidity and Abilities Implied in Scientific Method

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THIS study was projected because an aspect of psychology, the concept of rigidity, seemed to give an insight into the following question: Why do some students appear to be able to understand and utilize the scientific method and others do not? It is our conviction that resorting to the major theories and concepts of psychology would offer a good springboard to the understanding and possible solution of

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many of our educational problems. As the general field of psychology deals with responses to any and every kind of situation that life presents, including experiences and behavior of human beings in response to educational situations, this would be of special significance to problems dealing with learning and teaching.

One of the foremost problems in the development of educational science, or of any science for that matter, is that concerned with the building of a system of concepts, for it is through a conceptual system that there is gained the logical machinery by which the elements of experience are tied together in a related manner. The concept of rigidity is a basic concept utilized in such problems of personality structure as are presented in this study.

The easiest way to define rigidity is in its functional sense, that is, by the ways in which mental rigidity is manifested overtly. Functionally, it can be referred to as sluggishness in variation of response, fixation of response, lack of variability, inability to change one's mental set when the objective conditions demand it, and inability to rearrange a mental field in which there are alternative solutions to a problem in order to solve that problem more efficiently.

A number of workers in the field of rigidity as a personality factor have hypothesized that there is a general rigidity factor which will pervade many of the actions of the individual, both overtly and covertly. The work of Frenkel-Brunswik and Sanford [1], and Levinson and Sanford [2] indicate the possibility that rigidity of personality structure is an all pervasive phase of personality. These authors indicate that the differences between prejudiced and nonprejudiced individuals suggest that there would exist similar differences in the manner in which they would solve other types of problems that they would be confronted with.

The basic assumption of the work of Rokeach [3] was that one of the characteristics of ethnocentric (prejudiced) thinking is a rigidity and inflexibility of the thinking process. He stated that:

> The rigidity inherent in the ethnocentric persons' solution of social problems is not an isolated phenomenon within the personality but is rather an aspect of a generally persistent personality characteristic which will also manifest itself in the solution of all kinds of problems, even though such problems are completely lacking in social content.

It was primarily on the basis of the confirmation of the hypothesis of Rokeach, that the rigid thinking characteristic of the ethnocentric individual is also characteristic of his approach to non-social problems, that led to the present work.

In recent years the teaching of the scientific method in science courses has attained the status of an educational tenet. In the Department of Biological Science of Michigan State College where this investigation was conducted, "to teach the student to think scientifically" [4] has become a major educational objective. There are many and varied definitions of what is meant by the scientific method.

For the purposes of this discussion Cohen and Nagel [5] present the view that:

> Scientific method is . . . the persistent application of logic as the common feature of all reasoned knowledge. From this point of view scientific method is simply the way in which we test impressions, opinions, or surmises by examining the best available evidence for and against them. . . . in essence scientific method is simply the pursuit of truth as determined by logical considerations.

They state that there are other methods of arriving at truth. The method of tenacity is one in which habit and inertia makes it easier for individuals to continue to believe a proposition simply because it has always been believed. This carries with it the closing of the mind to all contradictory evidence. A second method, the method of authority, is one in which appeal for answers to questions is made to some highly respected source. This method is a simple and inflexible holding to authority. It breaks down when differing authorities appear. A third method sometimes used is

the method of intuition, or the appeal to 'self-evident' propositions. Examples of propositions believed in the past or at the present to be self-evident are: the orbits of planets are circular, the whole is greater than any of its parts, the earth is flat. Many 'self-evident' propositions have been and are being proved false upon testing. These three methods are all inflexible. None of them can admit the leading into error. None of these methods has provision for correcting its own results. The scientific method differs in that it is a technique which enables the discovering and the testing of possible alternatives to propositions. The scientific method is flexible.

The concept of rigidity has been shown to manifest itself by a rigidity, an inflexibility, a stereotypy of thinking. This pattern of thinking is contrary to the mode of thinking utilized in the use of the scientific method. The work of Frenkel-Brunswik shows that she finds that this may be true in that she apparently detects a relationship in the factors of ethnocentrism, rigidity of the thinking process, and scientific thinking. The work of Rokeach [3] also points out that rigidity of thinking is not confined to social situations alone, but rigid thinkers show an inflexibility of solution to other types of problems. The above indicates the possibility that individuals who are rigid in their patterns of thinking will not be able to utilize the scientific method in that both are incompatible, as the scientific method is a process of flexibility whereas rigid thinking is a manifestation of inflexibility.

The foregoing suggest that the hypothesis to be tested is: Those individuals who manifest a rigidity of the thinking process will react differently to the various factors concerned with the scientific method than those who are relatively less rigid in their pattern of thinking. The hypothesis was tested by comparing the performance of the groups specified as rigid and non-rigid on a test made up of items concerning and testing the various abilities implied in the scientific method.

Procedure. The first step consisted in establishing two groups of subjects: one group designated as relatively rigid in the thinking process, and the other group categorized as relatively non-rigid in its patterns of thought. Relative rigidity and non-rigidity were determined by an arithmetic technique utilized by Rokeach [3] and Luchins [6].

The fundamental plan of the arithmetic technique is to establish a set of conditions that would indicate, operationally, mental rigidity. Rigidity was defined by Rokeach "as the inability to change one's set when the objective conditions demand it, as the inability to restructure a field in which there are alternative solutions to a problem in order to solve the problem more efficiently" [3]. In order to meet the conditions imposed by this definition so that rigidity could be measured operationally in a non-social situation a variation of the Luchins' technique for the study of the Einstellung-effect was utilized [6]. The problems presented for solution involved the measurement of a designated volume of water through the manipulation of three jars of known capacities. Problems solvable by one complicated method were presented for solution in order to establish a mental set. These were followed by a number of problems, called critical problems, which are similar in appearance but solvable by a previously employed and simpler method. An example of the complicated type of problem in which there is only the complicated method of solution is as follows: Given are three jars with capacities of 31 quarts, 61 quarts and 4 quarts respectively. The problem is to obtain 22 quarts of water using these jars. The only correct solution is to fill the 61 quart jar, from this to fill the 31 quart jar and the 4 quart jar twice. There then remains in the 61 quart jar the required 22 quarts of water. If the first, second, and third jars are called A, B, and C, respectively, the method of solution would be B-A-2C.

The above set problems are followed by several critical problems, solvable by a simple method as well as by the rigid method. For example: the three jars have capacities of 23 quarts, 49 quarts, and 3

quarts, respectively, and the quantity of water required is 20 quarts. In this example, the rigid method of solution is 49–23–3–3 = 20. A subject who gives the B-A-2C solution to a critical problem in which a simpler solution is possible, may be said to be solving such a problem in a rigid manner. The simple method of solution is A-C.

The following instructions were given orally:

"This experiment is designed to see how well you can work simple problems without making mistakes. Your performance on this experiment will in no way affect your grade in this course.

"Imagine that you are standing beside a lake which has lots of water. In the first problem you are given three empty jars. The first empty jar has a capacity of 13 quarts of water. The second empty jar has a capacity of 29 quarts of water. The third empty jar has a capacity of 3 quarts of water. Write down in your own words on the first right hand page of your booklet how you would go about getting exactly 10 quarts of water. Do the problem in the easiest possible way. You do not have to use all of the three jars in order to solve the problem."

The experimenter then allowed two minutes for the working of the problem. At the expiration of the two minutes, problem two was presented. The experimenter then continued with:

"I will now explain how to do this problem (problem 2). The correct solution is to fill the 37 quart jar and from this to fill the 17 quart jar once and the 6 quart jar twice. There then remains in the 37 quart jar the required 8 quarts of water."

Here is another way the solution of this problem may be written: 37–17–6–6 = 8.

Each problem which I give you is to be worked on a new right hand page of your booklet. You will be allowed exactly 2 minutes to solve each problem. You are not allowed to turn any of the pages in your booklet except when I tell you to. Also, you are not allowed to go back to any previous problem on a previous page to change your answer or to fill in an omitted answer.

Turn over to the next right hand page. You may use the left hand side of your booklet for figuring and scratch work. Here is the next problem, Problem 3, see table I.

The second step consisted in the selection of thirty-three items testing the ability of the subjects to comprehend eighteen aspects of the scientific method as specifically concerned with problems in Biological Science. The thirty-three items selected covered the eighteen aspects of the scientific method and are listed in their operational form:

1. Ability to recognize a logical hypothesis.
2. Ability to recognize the best hypothesis among two or more alternatives.
3. Ability to recognize a statement that is not an hypothesis.
4. Ability to recognize an illogical hypothesis because it contradicts the data.
5. Ability to recognize data contradicting an hypothesis.
6. Ability to recognize data supporting an hypothesis.
7. Ability to recognize data unrelated to the hypothesis.
8. Ability to recognize a principle.
9. Ability to recognize a valid experiment.
10. Ability to recognize the results of an experiment.
11. Ability to recognize the probability factor in an experiment.
12. Ability to recognize causal relationships.
13. Ability to recognize a statement warranted by all or part of the data given.
14. Ability to recognize a statement contradicted by the data.
15. Ability to recognize a reasonable interpretation of the data.
16. Ability to recognize data insufficient to warrant any conclusion.
17. Ability to recognize statements going beyond the inferences to be drawn.
18. Ability to recognize a statement contradicted in whole or part by inferences based on one or more experiments.

Basic Assumptions of the Study. There are a number of assumptions that must be discussed in relation to the determination of the relative rigidity of the subjects. Before being justified in saying that we have two groups, highs and lows, that can be

TABLE I

Design of Problems Used in Determining Rigidity

Problem Number				The Problem	Type of Problem
1.	13	29	3	get 10	Control critical problem (Solvable both ways)
2.	17	37	6	get 8	Example
3.	31	61	4	get 22	
4.	10	39	4	get 21	Set Problems
5.	51	102	3	get 45	
6.	23	49	3	get 20	
7.	11	25	3	get 8	
8.	12	29	5	get 7	
9.	10	23	3	get 7	
10.	11	27	5	get 6	Critical Problems
11.	20	47	7	get 13	
12.	12	32	8	get 4	
13.	13	36	10	get 3	
14.	17	40	6	get 11	
15.	13	29	3	get 10	

compared on the basis of rigidity it is important that there is some assurance that both groups were measured in an equal manner and that the rigidity measured is in fact the defined rigidity. Therefore, a rigorous examination of a number of assumptions on which the measurement of rigidity is based is in order.

First, do the students comprehend the directions, and, secondly, is there a lack of arithmetical ability necessary to solve the problems presented. In either case, whether it be a comprehension or an arithmetical ability factor, it would manifest itself in a failure to solve one or more problems. Therefore, those subjects who failed to solve any of these problems were eliminated from further consideration. Thus the remainder were equal to the extent that they were all found capable of solving the problems presented to them.

Do all subjects have the ability to solve the problems in the simple, non-rigid way when the problem is actually solvable by both methods—and will actually solve the problem in a simple way when there is no set established? There must be some assurance that a rigid solution is due to an experimentally established mental set and that the problems would not, ordinarily, be solved rigidly unless preceded by set problems. This is accomplished by use of the control critical problem. Those individuals who solve the control critical problem by the simple, non-rigid method are retained for the experiment, those who use the complicated, rigid manner in solving the control critical problem are eliminated. There were some forty-nine eliminations on this basis. Therefore, by eliminating those subjects who solve the control critical problem by a rigid or complicated method, and by considering, in the statistical analysis, only those subjects who solve the control critical problem by the simple method, whatever differences in rigidity there may appear will have to be attributed to different strengths of a rigid Einstellung-effect experimentally induced. Thus, every subject retained in the analysis of the results demonstrated that he is able to solve the control critical problem non-rigidly.

A further assumption upon which this device rests is that there exists little or no relationship between the ability to solve the arithmetic problems and intelligence; little or no relationship between the arithmetic ability and such other qualities that the American Council On Education Psychological Examination For College Freshmen and the Cooperative Test of Reading Comprehension measures.

There is evidence that the results obtained are not attributable to the operation of an arithmetical ability factor. First, as the paper by Rokeach [3] indicates, a study was made in which cases from the Child Guidance Study and the Growth Study at the Institute of Child Welfare, University of California, were used. The correlation between arithmetical rigidity scores and the arithmetic score on the Wechsler-Bellevue was $+ .01$. Secondly, the results obtained in this present study show that the correlation between the Q-score of the American Council On Education Psychological Examinations (this score purports to measure abilities involved in quantitative thinking) and the arithmetical rigidity gave an r of $+ .013$ for the subjects of this report. These data indicate no correlation between rigidity as measured by the arithmetic technique and arithmetical ability as measured by the above mentioned instruments.

This study is based upon the assumption that the results obtained are due to a general rigidity factor and not to a general intelligence factor. Rokeach [3] presents evidence gained from the Child Guidance and Growth Study cases to support this. The Pearson product-moment correlation between rigidity as measured by the arithmetic technique and the Stanford-Binet IQ is $-.19$; between rigidity and the Wechsler-Bellevue IQ is $-.13$. Additional information obtained from the present study corroborates these findings. The correlation between the T-score of the American Council on Education Psychological Exam-

ination, which is a measure of general college ability and rigidity, was found to be — .028. Thus the assumption that there is no significant correlation between intelligence and rigidity as measured by the arithmetic technique appears to be borne out.

Other qualities measured by the American Council On Education Psychological Examinations and the Cooperative Test of Reading Comprehension and rigidity as measured by the arithmetical technique were correlated. The r of the L-score, measuring linguistic abilities, and rigidity was + .198; between general reading ability and rigidity was — .189. None of these differences are significant, indicating that in these qualities also there is little relationship, if any, to rigidity.

A study of the results of this measurement of rigidity shows that the mean number of problems solved non-rigidly by the entire group of 253 subjects is 5.62 out of ten problems. The group was arbitrarily divided into two equal categories, rigid and non-rigid. This was determined by ascertaining whether the subject obtained a score falling above or below the median of all subjects participating in a given experiment. The mean number of problems solved non-rigidly by the rigid group of all the subjects was 1.41 problems, and the mean number of problems solved non-rigidly by the seven non-rigid group is 9.48. The total possible number of problems that could be solved non-rigidly was ten problems.

A discussion of the basic assumptions underlying the items selected for the testing of the abilities implied in the scientific method follows. It is assumed that the elements of the scientific method selected are actually the necessary elements of the scientific method. A review of the literature on this subject appears to the writer to bear out this assumption. The elements utilized in this report have been explicitly chosen by the Department of Biological Science at Michigan State College as objectives to be taught and tested. Much work has gone into the program of the selecting, teaching, and testing of the factors of the scientific method. There is general and specific agreement of the factors listed here with the factors listed by Burmester in her work on the development of an objective examination to test as many phases of the scientific method as can be tested by objective tests. The work of such men in the field as Tyler [7], Keesler [8], Glaser [9], and the Committee on the Function of Science in General Education [10], Fruchtey and Tyler [11], and Zyve [12] also show that the elements listed for the study being reported are the most frequently mentioned elements of the scientific method.

A second assumption concerns the reliability and validity of the items under consideration. They are considered reliable and valid on the basis of the following. The split-halves method of determining reliability was used on the thirty-three items utilized. In determining the reliability the questions were first ranked in order of their degree of difficulty. Two half scores of each subject was obtained by utilizing the odd-even method. The coefficient of correlation of these was .952. For the estimated reliability of the entire test the Spearman-Brown formula was applied and found to be .975. This would indicate high reliability. The staff of the Department of Biological Science of Michigan State College has indicated that the items are valid as to the measurement of the elements of the scientific method as far as they can be measured by an objective multiple-choice test.

An analysis of the items of the study shows that they utilize a good deal of subject matter in dealing with the factors of the scientific method. It may be argued that what is being measured, as far as the rigid and non-rigid groups are concerned, is a subject matter differential. This, indeed, is a serious concern of the study and of studies of a similar nature where there is an attempt to dissociate verbals from patterns of thinking. It may be recalled that

there is little or no statistical difference between the two groups as concerns the various attributes measured by the American Council on Education Psychological Examinations for College Freshmen and the Cooperative Test of Reading Comprehension. These include such factors as quantitative thinking, linguistic abilities, general college ability, recognition vocabulary, rate and level of comprehension, and general reading ability. From this lack of significance it can be inferred that the two groups, rigid and non-rigid, have a similar body of factual information for as far as can be told they have had equal opportunity for the acquisition of this information with evidently similar abilities for understanding of this information.

Results. Table II presents a comparison of the behavior of the rigid and non-rigid groups, on the items presented in the section on the Design of the Study, testing the elements of the scientific method. An inspection of Table II will show that, in general, the difference between the rigid and non-rigid groups is in the hypothesized direction. Four items were significant at the 10% level. On the basis of standards previously set up while there is no rejection of the null hypothesis at this level, there is, however, a trend towards the rejection. Twenty of the items were significant at the 5% level or above: thirteen were at the 5% level, four at the 2% level, and three were at the 1% level. In these twenty items the null-hypothesis can be rejected. Only in nine of the thirty-three items was there no significant difference at all.

It is interesting to note from Table II that, in all but one case, where more than one item was used to test an element of the scientific method and one item was found to be not significant, all items were not significant for that particular factor.

The above data suggest that in general there is agreement with the hypothesis that rigid and non-rigid groups will react differently to the elements of the scientific method—that the non-rigid group will be able to utilize the elements of the scientific method more efficiently than the rigid individuals. To support this hypothesis on the level of the total number of factors and items involved in the testing of these factors of the scientific method, the calculation of the standard error of the difference of the means was resorted to. The critical ratio was found to be 5.238. With the 1% level at 2.58 it is readily seen that a critical ratio of 5.238 on the entire test the null hypothesis can certainly be rejected. Statistically the non-rigid group has done considerably better than the rigid group of individuals.

TABLE II

COMPARISON OF RIGID AND NON-RIGID GROUPS ON ITEMS TESTING THE ELEMENTS OF THE SCIENTIFIC METHOD

N Rigid 59 N Non-Rigid 59

Problem *	Number of Correct Solutions		Chi-Square	Significance Level
	Non-Rigid	Rigid		
1a	43	29	7.26	1%
1b	46	35	4.762	5%
1c	43	33	3.694	10%
1d	22	10	3.924	5%
2	43	32	4.424	5%
3a	25	14	4.62	5%
3b	23	12	4.84	5%
4	48	38	4.286	5%
5	17	9	3.165	10%
6	34	22	4.88	5%
7	35	24	4.08	5%
8a	25	13	5.58	2%
8b	27	16	5.00	5%
9	9	8	**	**
10	48	50	**	**
11a	23	14	3.188	10%
11b	37	24	5.64	2%
11c	28	17	3.99	5%
12a	35	24	4.08	5%
12b	42	32	3.622	10%
12c	35	21	6.66	1%
13	53	41	7.52	1%
14	35	35	**	**
15a	49	51	**	**
15b	35	37	**	**
15c	25	31	**	**
16a	47	35	5.74	2%
16b	45	42	**	**
16c	46	35	4.762	5%
17a	43	48	**	**
17b	43	45	**	**
18a	38	25	5.74	2%
18b	36	24	4.6	5%

* Test items for individual aspects of scientific method.

** Not significant.

The results seem to indicate that the ability to utilize the elements of the scientific method is a manifestation of a general rigidity factor. This is supporting evidence for the conclusions reached by Frenkel-Brunswik, "The ability to question matters and the need for definite dogmatic answers as frequently found in high scorers, leads either to an easy acceptance of stereotyped, pseudoscientific answers, of which escape into ready made hereditarian explanation is but one manifestation, or else to an explicitly *unscientific* attitude. . . . Its opposite is a *scientific naturalistic attitude,* found predominantly in low scorers. . . ." [1] The results presented in this study lend a good deal of experimental and statistical evidence to the results found by Frenkel-Brunswik and others.

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ANNUAL NARST MEETING

The 1953 meeting of the National Association for Research in Science Teaching will be held at the Chalfonte-Haddon Hall, Atlantic City, New Jersey, February 15, 16, and 17. The dinner meeting will be on Sunday, February 15, at 6:30 P.M. Members who have papers to present, or know of people who should or might present papers, please write NARST President:

PROFESSOR J. DARRELL BARNARD
School of Education
New York University
Washington Square East
New York, New York

or

DR. KENNETH E. ANDERSON
107 Fraser Hall
University of Kansas
Lawrence, Kansas

Dinner reservations should be made by writing the Secretary.

Hotel reservations should be made by writing "Housing Bureau, American Association of School Administrators, 16 Central Pier, Atlantic City, New Jersey." Indicate several preferences. Single rooms at Boardwalk hotels usually begin at $6.00 and double-rooms at $8.00. Avenue hotel rates respectively begin at $5.00 and $7.00. Boardwalk hotels include Chalfonte-Haddon Hall, Ritz-Carlton, Traymore, Claridge, Strand, Seaside, Mayflower, President, Brighton, Shelburne, Breakers. Avenue hotels include Clarendon, Colton Manor, Flanders, Jefferson, Madison, Morton, and Senator.

DIGESTS OF INVESTIGATIONS IN SCIENCE EDUCATION *

An Evaluation of Science Courses Offered for General Education in Selected Negro Colleges

William Fauntleroy Goins, Jr.

Problem

The purpose of this study was *to evaluate, in the light of certain criteria, the science courses offered for general education in a selected group of Negro colleges.* Important sub-problems were:

1. To develop a set of evaluative criteria for general education science courses from a theory of general education and selected writings in the area of science education.
2. To devise an evaluative technique which would be appropriate to the purpose of the problem.
3. To find out which Negro colleges provide science courses in their general education programs and to select a representative sample of these colleges for study.
4. To evaluate the science courses in the selected colleges by the criteria.
5. To isolate trends and propose recommendations for these and other colleges interested in studying or revising their general education programs.

Procedures and Techniques

A theory of general education was formulated to serve as a philosophic background from which to project the evaluative criteria. This theory was developed through an examination of the characteristics of modern man and society, an identification of certain needs which arise from the interaction of the individual and society, and a consideration of the role of science in a program of general education based on student needs. The characteristics of a general education program consistent with student needs were defined in terms of criteria or guiding principles. A check list was used in personal interviews to secure information for evaluation. Forty-eight representative Negro colleges comprising fifty-four percent of all Negro colleges offering general education courses were visited. Data about the science courses for general education were collected by individual interviews with members of the faculties. The colleges were evaluated individually, and by groups according to types.

Results

1. When the colleges were evaluated on such features as whether courses were based on student needs; presence of broad integrative elements; emphasis on laboratory experiences and quantitative data; whether courses were required; length of courses; and use of instructors, very few received high ratings on any item except "use of instructors."
2. From the evaluation of instructional aspects, the following results appeared:
   a. Few institutions showed evidence of student-teacher planning in their science courses.
   b. The majority of the colleges provided for individual differences of students only incidentally.
   c. Very few courses made adequate use of the local environment.
   d. The use of textbooks and syllabi was satisfactory.
   e. A minority of the colleges possessed adequate work materials and equipment, with the majority being weak in physical facilities.
   f. In general, teaching procedure was poor, with evaluation practice quite inadequate and based on a philosophical concept of teacher-set standards rather than on student growth.
3. With respect to meeting student needs in the four basic areas of living, the majority of the colleges were weak in all areas except that of developing a range of interests.
4. In development of the personal characteristics essential for democratic living, the

* The digests of the studies by Goins, Adams, Hausdoerffer, and Leonhardy were prepared by a committee having as its chairman Professor W. C. Van Deventer, Stephens College, Columbia, Missouri. The digests of studies by McCarthy, Matthews, and Lee were prepared by a committee having as its chairman Professor N. Eldred Bingham, School of Education, University of Florida, Gainesville, Florida.

majority of the colleges were weak in the development of ability to do reflective thinking, the development of creativeness, and the development of social sensitivity. The ratings were better on development of self direction and cooperativeness, but in many cases these values were not purposely stressed.

5. In the evaluation of the colleges as groups according to type, the groups seemed to be essentially equal.

Conclusions

1. The general education programs of the several colleges studied suffer from the lack of a well-formulated, clearly-understood philosophy of general education.
2. The quality of the general education science courses in the colleges suffers because of inadequacies in equipment and supplies.
3. The general low level of the colleges with respect to adequately meeting student needs in general education is partially due to factors such as overcrowded classes, overburdened teachers, lack of qualified teachers, inadequate facilities, attitude of some teachers that the general courses are inferior to "standard courses," inadequate evaluation procedures, and dearth of attention given to social values.
4. Too little time is allocated in most of the colleges to the general education science courses.
5. Negro colleges are becoming increasingly aware of the shortcomings of their general education courses and more sensitive to the requirements of an adequate general education program.

A STUDY OF VARIOUS FACTORS RELATED TO SUCCESS IN COLLEGE PHYSICS

SAM ADAMS

Institution: Louisiana State University

Date of Completion: February 1, 1951

Statement of Problem: What relationships, if any, exist between success in college physics and various measurable features of the personal and scholastic backgrounds of students?

Methods and Techniques: This study dealt with 877 students who took one of the two-semester courses in beginning physics at Louisiana State University between 1947 and 1950. The following items were investigated regarding this group:

A. Marks in first year college mathematics
B. Marks in high school courses, including
   1. Physics
   2. Chemistry
   3. Second year algebra
   4. Senior English
C. Averages in high school fields, including
   1. Mathematics
   2. Science
   3. English
D. Rank in high school class
E. Percentile ranks on college entrance tests, including
   1. Reading
   2. English
   3. Chemistry
   4. Mathematics
   5. Psychological (total test)
   6. Psychological (quantitative thinking)
   7. A composite of all entrance tests
F. Personal background items, including
   1. Age
   2. Veteran status

Numerical equivalents for semester marks ($A = 4$ to $F = 0$) were established; a student's achievement, or year mark, in a particular course was obtained by adding the numerical equivalents of his semester marks in that course. Decile ranks were used for entrance tests.

Findings: The following coefficients of correlation, with respect to marks in college physics, were found:

1. Marks in first year college mathematics	.435
2. Marks in high school physics	.324
3. Percentile rank in class	.306
4. Marks in second year high school algebra	.290
5. High school mathematics average	.279
6. High school chemistry marks	.263
7. Mathematics entrance test ranks	.258
8. Senior English marks	.247
9. High school English average	.241
10. Composite rank on entrance tests	.214
11. High school science average	.204
12. Rank on chemistry entrance test	.187
13. Rank on English entrance test	.154
14. Rank on psychological test (total)	.130
15. Rank on psychological test (quantitative)	.121
16. Rank on reading entrance test	.077

A. When interpreted in terms of their probable errors, all of these coefficients except the last one could be considered significant.

B. The only age group showing superior work in college physics was 26-or-above. No notable differences in achievement be-

tween veteran and non-veteran groups were found.

C. The mean year mark in college physics for students having high school physics was 4.856; for those without high school physics, the mean was 4.758.

Conclusions:

A. Articulation between college physics and various types of high school work was found to be relatively poor (r's ranged from .324 to .204).

B. Despite this fact, high-school marks appeared to tell more about probable success in college physics than did entrance test ranks (r's on tests ranged from .214 to .077).

C. There was little or no difference in college physics achievement between those who had a year of high-school physics and those who did not have it.

D. A relatively high relationship appeared to exist between achievement in college physics and that in college mathematics ($r = .435$).

E. Veteran status did not appear to be a factor in physics achievement. The mean year mark for veterans was 4.72; for non-veterans, it was 4.78.

F. The only age group showing definitely superior work in college physics was 26-and-above. This group's semester average was approximately one letter grade higher than that of their nearest competitor.

THE MATHEMATICAL CONTENT OF TWO GENERAL COLLEGE PHYSICS TEXTS

WILLIAM H. HAUSDOERFFER

State Teachers College, Trenton, New Jersey

Institution in which the study was made: Rutgers University, School of Education.

Date of completion of study: May 1950.

Problem: What mathematical facts, skills, and concepts are required to cope with the expositions and problems contained in the college physics texts examined? *

Methods and Techniques:

In order to determine what mathematics is necessary for a rich comprehension of the texts, each text, including all of the problems, was analyzed with respect to mathematical vocabulary, mathematical variation, mathematical notation, mathematical skills and concepts, formulas from mathematics, the type of equations to be solved, and the complexity of the problems as judged by the number of steps required for their solution.

The findings of this study were compared with several earlier studies of a somewhat similar nature, and in no significant instance was a finding or conclusion of this study controverted by any of the previous investigations, although there are several findings and conclusions presented in this report which were not embodied in the earlier studies.

Partial findings:

1. *Mathematical vocabulary.* The mathematical expressions used are within the ordinary reading experiences of young people and adults. However, some of the terms are used with a more precise meaning than they are ordinarily.

2. *Mathematical variation.* Mathematical variation is employed freely, particularly variation of the first and second degree, both direct and inverse. It is necessary for the student to be able to convert a statement of variation into an equation, and vice versa. This ability involves an understanding of the proportionality factor. It is also important for the student to be able to comprehend a chain of variations such as: X is proportional to Y; Y is inversely

* Oscar M. Stewart, *Physics, A Textbook for Colleges* (4th edition; Ginn & Co., 1944) 785 pp.
Lloyd W. Taylor, Physics, the Pioneer Science (Houghton Mifflin Co., 1941) 847 pp.

proportional to the square of Z; therefore, X is also inversely proportional to the square of Z.

3. *Factoring.* The only case of factoring encountered is that of factoring a common monomial from a polynominal, which is far removed from the complicated cases treated in many mathematics classrooms.

4. *Conversion of units.* The ability to convert units with facility is extremely important.

5. *Trigonometric concepts and skills.* Trigonometric applications center about radian measurements, and the sine, cosine, and tangent functions.

6. *Formulas from mathematics.* Every formula from mathematics used with frequency is elementary and is commonly introduced in the junior high school.

7. *First degree equations.* The majority of equations are of the first degree, and, in general, are of the type usually presented in first year algebra texts, although the numerical coefficients are frequently common fractions, decimal fractions, or standard numbers.

8. *Second degree equations.* The second degree equations encountered are also elementary in the sense that all but about one per cent of them can be reduced to a simple form such as $3x^2 = 36$.

9. *Simultaneous equations.* The conventional form of simultaneous equation, $3x + 26 = 16$ and $2x + 4y = 12$, occurs infrequently. In many instances the forms involve fractions containing one or two variables, trigonometric functions, or subscript notation.

10. *Logarithmic and exponential equations.* Logarithmic and exponential equations are used very infrequently and in relatively unimportant cases.

11. *Equations higher than the second degree.* Equations higher than the second degree are almost non-existent, and the few that do occur are of the special type such as $2x^3 = 39$.

12. *Standard numbers.* The operations of multiplication and division involving standard numbers appear with great frequency.

13. *Slide rule.* The nature of the mathematical operations and combinations thereof suggest the advantages of using the slide rule.

14. *General nature of the problems.* Multi-step problems predominate, although the level of the calculations involved is elementary, of the type usually encountered in the first or second year of high-school mathematics.

Conclusions:

1. The mathematical calculations that must be performed by the student using any of the texts examined involve skills, facts, and concepts usually associated with junior-high-school or high-school mathematics.

2. High-school mathematics texts stress many topics that are either ignored or almost ignored in college physics texts, and vice versa. This provides some justification for reconsidering the content of high-school mathematics texts as well as college physics texts. Among the topics that are virtually ignored in the work of the physics texts examined are the following: factoring, trigonometric identities, multiple angle formulas from trigonometry, the general quadratic equation, special products, binomial theorem, permutations and combinations.

3. If a particular mathematical concept, fact, or skill is not needed for the work associated with physics texts, it is not concluded that this particular item be dropped from the mathematics program. Instead it is suggested that justification for retaining the item under question be sought elsewhere.

4. The student of general college physics would be greatly aided if his mathematical background included significant experiences with standard numbers, vectors, conversion of units, mathematical variation, radian measurement, simultaneous equa-

tions of the unconventional type, the slide rule, and notation involving the use of Greek letters and prime notation.

5. College physics requires a fair degree of mathematical maturity in that the student is left to his own mathematical resources without the indication frequently found in mathematics texts that certain problems are going to involve particular concepts, skills, and facts. Maturity is also required to analyze the many multi-step problems.

THE MATHEMATICS USED IN THE HUMANITIES, SOCIAL SCIENCE, AND NATURAL SCIENCE AREAS IN A PROGRAM OF GENERAL EDUCATION ON THE COLLEGE LEVEL

ADELE LEONHARDY

Institution and date: University of Missouri, 1950.

Problem: To determine what basic mathematical concepts and processes are in the textbooks used in three areas of general education in a selected group of colleges and universities and the implications of the results for teachers of mathematics.

Method of research: While the study is primarily a frequency study of the mathematical concepts and processes found in the selected textbooks, frequency of occurrence has been only one of the factors which have been considered. Two other criteria—occurrence in at least three of the four areas of the humanities, social science, and biological and physical science and in seventeen of the thirty-five books examined—were also applied in determining lists of the essential mathematical concepts and processes needed as a minimum.

Summary of findings:

(1) Mathematics is used extensively in each of the areas of general education. Physical science has the highest mathematical content per page, with biological science, the humanities (applied aesthetics), and social science following in order.

(2) The combined data for the textbook material show that approximately three-fourths of the mathematics used is quantitative, one-fifth is the mathematics of spatial relationships, and one-twentieth deals with logical structure. Biological and physical science agree with these results, while social science shows an even greater trend toward the quantitative. The humanities tends to reverse these results with three-fourths of the mathematics in this area referring to spatial relationships.

(3) Lists of essential mathematical concepts and processes were determined for each of the areas and for the combined areas. The seventy-nine items on the list for the combined areas meet 74 per cent of the mathematical needs in the textbook material in the humanities, 89 per cent in social science, 86 per cent in biological science, 75 per cent in physical science, and 83 per cent in the combined areas.

(4) The mathematics required for general education is relatively simple, for it is the arithmetic of the elementary school and certain concepts and processes from each of the four years of high-school mathematics. Listed by subject fields, the needs are:
Arithmetic: Facility in the fundamental operations with integers, fractions, and decimals, and an understanding of small numbers (.001 or less) large numbers (500,000 or more), the comparison of two quantities, the first two cases of percentage (finding per cent of a number and finding what per cent one number is of another), and the arithmetic of measurement.
Algebra: Positive and negative numbers and those phases of algebra which are the basic ideas underlying the function concept and the means of representing these quantitative relationships by means of principles stated in words, tables, line graphs, formulas, direct and inverse proportions, and variation.
Geometry: The recognition of geometric forms and the relationship of points, lines, and planes in three-dimensional space, as well as the recognition of two-dimensional figures and the relation of points and lines in a plane.
Trigonometry: An understanding of circular functions as related to periodic phenomena in sound, light, electricity, etc.
Statistics: An understanding of *average* (mean), *maximum, minimum,* and *range*.

(5) The student who enters college without preparation in essential mathematics will be handicapped in programs of education such as that represented in the present study, unless provision for remedying the deficiency is made.

Recommendations:

(1) Competence in certain elementary concepts and processes of mathematics should be one of the objectives of a program of general education.

(2) Provision for the college student who is deficient in mathematics may be made in several ways:

(a) The teachers in the general education areas may teach the mathematics when and where it is needed.

(b) The mathematics department may provide a service course for the combined areas of general education.

(c) The mathematics department may offer a combination service course and one which also presents mathematics as one of the areas of general education.

(3) If the mathematics department takes the responsibility for the more general mathematical needs of the areas of general education, the faculty of each individual area may be responsible for the mathematics more specifically related to the area.

(4) Means should be devised for determining the mathematical concepts and processes of potential value for the college student in the program of general education. This should include the mathematics which would be of value to the general student *if* it were a part of his equipment.

Age Placement of Selected Science Subject Matter

Francis W. McCarthy

Submitted in partial fulfillment of requirements for Ed.D. degree, Graduate School of Education, Harvard University, June, 1951.

Study suggested by Dr. Fletcher G. Watson.

The problem investigated by this experimental study may be expressed thus: Where can certain facts and principles of science be taught profitably for the first time?

The study presents a technique of investigation, rather than a comprehensive list of topics. Most of the testing was with children in the second grade of an elementary school in Boston. Near the end of the experiment children in kindergarten, grades one, three, and four, were tested by the same techniques.

Three experiments were selected as having simplicity of concept, ease of demonstration, and a minimum of complex reasoning. The devices used were the lever, the pulley and the inclined plane. Simple apparatus, toy figures representing persons, and clear drawings, were employed.

The technique included: (a) a pre-test, chiefly questions before manipulation to discover background and arouse interest; (b) manipulation of the apparatus; (c) confirmation of the results by discussion, to prove understanding; (d) a post-test given six weeks after the experiment, using pictures.

One child at a time was tested. Selected records of conversations are given, showing an excellent and understanding approach. "Point to the place where the big boy would sit on the see-saw," is an example. The tests were not long; for the lever, 85 per cent of the tests were completed satisfactorily in 12 minutes; for the pulley, 70 per cent completed in 10 minutes, for the inclined plane, 90 per cent completed in 9 minutes.

The influence of mental age on ability to understand these concepts is pronounced. Computations imply that 100 per cent performance would be achieved at a mental age of 8 years 6 months. This per cent decreased with lower mental age. The age of zero performance was approached, but not established by data. The 50 per cent performance is at a mental age of 7 years 6 months.

The conclusion is that these three experiments, giving concepts concerning Work as defined in physics, are suitable for the second grade. Similar investigations could establish the suitability of other scientific concepts for definite grade levels. It is obvious that tens of thousands of such investigations could be planned and carried out.

Minor observations are these:

Children show a high level of interest in a science demonstration;

Children have difficulty in judging the size and weight of objects;

Children often find it easier to demonstrate an answer on apparatus than to express the answer in words. Oral and written knowledge should not be the sole criteria of understanding science;

Manipulation of apparatus by children is clumsy because their muscular coordination is low, hence any apparatus used in the lower grades should be sturdy, and easily arranged.

The author suggests the following concepts as being very suitable for a study using the technique he has developed:

expansion due to heat
reflection of light by opaque bodies
refraction of light by transparent bodies
magnetism
buoyance of objects immersed in liquids

The review of background literature in respect to science instruction in the grades is very comprehensive. The study has been carried out with great patience and understanding. It is a distinct contribution to the technique of investigating the place of science in the elementary grades.

A TECHNIQUE FOR EVALUATING THIRD GRADE CHILDREN'S UNDERSTANDING OF SOME SCIENCE TERMS AND PRINCIPLES *

UNA MAE MATTHEWS

Robert E. Lee School, Austin, Texas

Science education in the elementary school serves a very useful purpose in helping to orient the child to the world of nature in which he lives from day to day. The child sees the manifestations of science in the home, the school, and the community and develops certain concepts relating to science terms and principles. Frequently those who write textbooks and prepare curriculum materials in science for elementary school children do not have adequate information concerning science terms and principles which are understood by children at various age levels.

In addition to evaluating in some manner the understanding of science terms and principles a need was felt for the teacher to guide children in scientific thinking and to help them develop scientific attitudes; then use the information gained to plan a more meaningful science program by starting where children are, and challenge them to constantly move forward to higher thinking and greater understanding.

* A Master of Education study completed at the University of Texas, 1951.

The principle "Heat from the Sun is the Chief Source of Energy for the Earth" was selected from the Thirty-second Yearbook of the National Society for the study of Education.

The following concepts are contained in the above principle:

1. Heat from the sun causes surface water to evaporate.
2. Water vapor rises, cools, forms clouds.
3. Water which falls on the surface of earth collects in small streams.
4. Flowing water moves things.
5. Electricity is carried by wires.

The tests were given in the form of games and more than one approach to each concept was made. This was done by using pictures and questions and encouraging each of twenty children taking the tests to talk freely so that the interviewer could gain some insight to the child's understanding.

Approximately three weeks after the children took the test a second test was given and in each instance there was slight improvement. It seemed there was a better conception of certain science terms. During

the first testing some children understood processes but did not seem to understand some of the terms such as evaporation, generators, transformers. In the second interview the processes and terms both were mentioned with understanding.

Evaluation of responses showed the different levels of understanding in all the phases, thus giving bases for beginning the years science program. As an example, when the question, What are clouds made of?, was asked, it was found that some children thought clouds were made of smoke, air, and mist. To the question, Why does it snow instead of rain?, some children understood that cold and hot air mix causing rain; also that increased cold causes sleet, snow and hail.. This gave insight to the different levels of understanding and how to take children on from where we find them.

Thus the testing program was found to be quite revealing as to third grade children's understanding of science terms and principles and the tests represented a resource for learning into which children enter enthusiastically and with much interest.

A Study of Science Interests of Third Grade Children at Longfellow School Revealed Through Science Experiences in Animal and Plant Life *

Louise Lee

There is an increased emphasis on science as an integral part of the elementary school program, either as a separate subject or in combination with social studies, or some other area. Effort is being made to use actual experiences whenever possible to make the learning in science more meaningful. Persistent effort is being made to fit the science offerings and the learning methods to the needs, interests, and abilities of the learners.

It was the purpose of this study to attempt to determine children's interests in animal and plant life as revealed through science experiences of a group of thirty-two third grade children at Longfellow School in Albuquerque, New Mexico. The study extended over a period of sixteen weeks. The first eight weeks were spent on the study of animal life and the second eight weeks on the study of plant life.

Throughout the sixteen weeks a record was kept of the study of any activity indicating group or individual interest in animal and in plant life. In order to show the frequency with which the children showed interest in observing, discussion and generalization, collecting, excursions, reading, graphic expression, writing, music, dramatic play, experimenting, miscellaneous experiences, identification, visual aids, and in caring for animals and plants, findings were tabulated under two main headings, Animal Life and Plant Life.

Detailed lists were made to show the different types of science experiences with animal and plant life. Three tables summarize the data. Tables I and II show the frequency of each type of experience with animal and plant life and Table III is a summary of the types of activities.

The investigator recognizes the fact that there are always limits in any classroom situation. The selection of activities and the richness of the environment will increase or alter the interests of the group. An understanding of the developmental tasks faced by children at successive levels of maturity must be considered by the teacher in guiding class activities which will meet the needs of the group and of individuals. Many science experiences can be treated in such a way as to appeal to children who are at different stages of maturity.

* A Master of Arts study at the University of New Mexico, Albuquerque, New Mexico, 1951.

Data from this study seems to warrant the conclusion that through the child's science experiences his natural interests are broadened. Material evidences of interests were shown in the form of pictures, books, and animals brought to school for classmates to observe. Booklets made by the children showed a wide range of interests in animal and plant life. Spontaneous expressions of ideas and understandings during class discussions were also indications of science interests.

Findings warrant the conclusion that in the study of animals first hand experiences created the most interest. Animals which were observed in the classroom, at the zoo, or at the circus were most interesting to the children. Observation, discussion, and reading were the most important types of experiences which this group of children had during the study of animals.

Also in the study of plants first hand experiences created the most interest. Experiments carried on during the study of plants provided better understanding of plant growth and development.

BOOK REVIEWS

VISHER, STEPHEN SARGENT. *Indiana Scientists.* Indianapolis, Indiana: Academy of Science, The State Library, 1951. 286 p.

This is a biographical directory and an analysis of Indiana Scientists. Brief biographical sketches of scientists born in Indiana, college or university-trained in Indiana, or employed there, comprise the bulk of this volume. In addition, there are analyses of these scientists by where they were trained, by science, and by places of birth and work. Some of the influences which apparently or obviously contributed to their achievement are also discussed. Brief summaries of the contributions of Indiana scientists in certain sciences are also given, as are summaries of the contributions made by various institutions. Approximately 4500 scientists are sketched.

Altogether *Indiana Scientists,* one of the very few similar publications in the United States, represents a tremendous amount of work. The author is one of America's best known geographers as well as one of the most prolific writers among American geographers. *Indiana Scientists* will serve a most useful purpose as a directory and work of reference. Scientists in other states would do well to emulate Dr. Visher in preparing similar biographical sketches for the eminent scientists of their states.

BURNETT, R. WILL. *Combatting Prejudice Through Science Teaching.* Washington, D. C. (1201 Sixteenth Street, N. W.): The National Science Teachers Association, 1952. 31 p. $1.00.

Much attention has been given in recent years to the problems of inter-group relations. Prejudice seems to be everywhere present, affecting profoundly most aspects of our National life. Attempts have been made in numerous instances in schools to remove or at least lessen the prejudices students have toward other groups. Much success has attended these positive teaching efforts. But the problem is so big and the attempts at teaching inter-group relations so sporadic that, by and large, we can only say that relatively little has been done.

Dr. Burnett believes that science classes, especially biology classes, offer an excellent medium for teaching inter-group relations. The heredity phases of biology offer an excellent opportunity for teaching about race prejudice. "Common learnings" or "effective-living" courses and social studies also afford similar opportunities.

This pamphlet presents an excellent discussion of the whole problem of race prejudice, and offers practical suggestions as to classroom procedures. Possibly science is the area in which the most effective efforts can be made in teaching inter-group relations. Notable progress in this area alone would more than justify the inclusion of science in the school curriculum. The reviewer is in perfect accord with Dr. Burnett's thesis and commends him for his functional approach to the problems of race prejudice.

LYNDE, CARLETON JOHN. *Science Experiences with Inexpensive Equipment, Science Experiences with Home Equipment and Science Experiences with Ten-Cent Store Equipment.* Scranton, Pennsylvania: International Textbook Company, 1951. 266 p., 230 p., 262 p.

This is the second printing of a series of books first published in 1939. So popular were the books that copies of the first printing were exhausted. Now they are made available again, much to the gain of science teachers. They are unique and no place else will science teachers find a better description of numerous experiments and activities in the physical sciences. General science, physics, and elementary science teachers find these books especially useful.

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